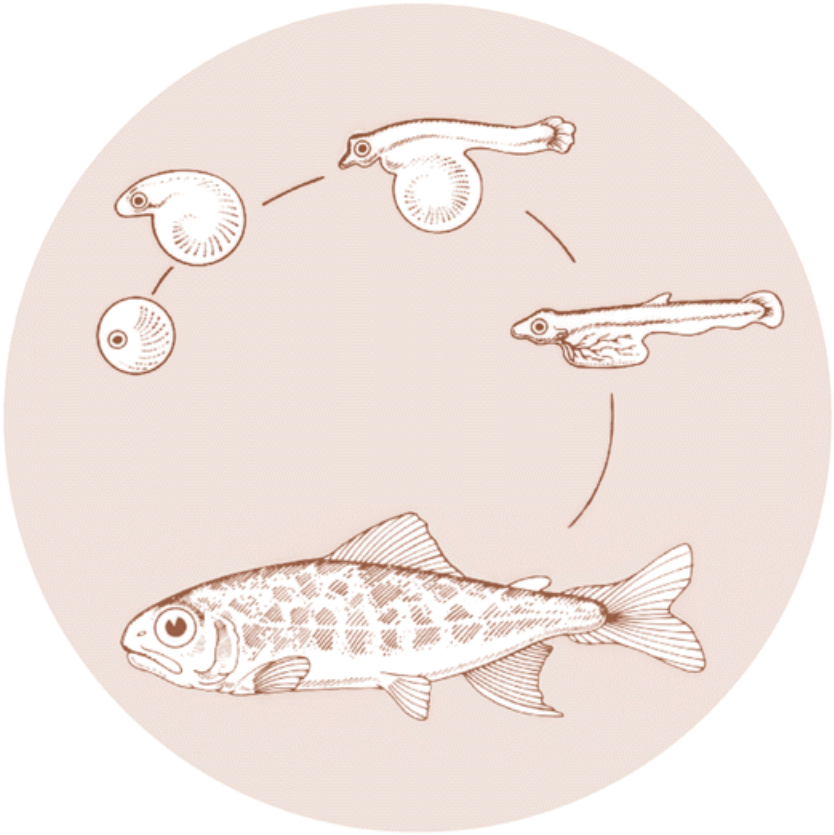
March 1993

FISH RESEARCH PROJECT - OREGON
UMATILLA HATCHERY MONITORING AND EVALUATION

Annual Report 1992



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Environment, Fish and Wildlife Division
P.O. Box 3621
905 N.E. 11th Avenue
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FISH RESEARCH PROJECT - OREGON
UMATILLA HATCHERY MONITORING AND EVALUATION

ANNUAL REPORT 1992

Prepared by:

MaryLouise Keefe
Richard W. Carmichael
Rod A. French
Warren J. Groberg
Michael C. Hayes

Oregon Department of Fish and Wildlife

Prepared for:

U.S. Department of Energy
Bonneville Power Administration
Division of Fish and Wildlife
P.O. Box 3621
Portland, OR 972X3-362 I

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EXECUTIVE SUMMARY

This report covers the first year of comprehensive monitoring and evaluation of the Umatilla Hatchery. As both the hatchery and the evaluation study are in the early stages of implementation, much of the information contained in this report is preliminary. The most crucial data for evaluating the success of the hatchery program, the data on post-release performance and survival, is yet unavailable. In addition, several years of data are necessary to make conclusions about rearing performance at Umatilla Hatchery. The conclusions drawn in this report should be viewed as preliminary and should be used in conjunction with additional information as it becomes available. A comprehensive fish health monitoring regimen was incorporated into the monitoring and evaluation study for Umatilla Hatchery. This is a unique feature of the Umatilla Hatchery evaluation project.

Objectives for FY 1992

1. Document egg-take, and egg-to-fry and egg-to-smolt survival rates for fall chinook, spring chinook, and summer steelhead reared at Umatilla Hatchery and released into the Umatilla River.

2. Document rearing densities and loading factors for fall chinook, spring chinook, and summer steelhead reared at Umatilla Hatchery and released into the Umatilla River.

3. Document number, size, time, and release location for fall chinook, spring chinook, and summer steelhead reared at Umatilla Hatchery and released into the Umatilla River.

4. Monitor water quality parameters in an index series of Michigan and Oregon raceways in which fall and spring chinook are reared, and in a series of Michigan raceways in which summer steelhead are reared.

5. Collect and compare monthly measurements of length, weight, and condition factors for fall and spring chinook reared in the Michigan and Oregon systems, and for summer steelhead reared in the Michigan system at Umatilla Hatchery.

6. Calculate and compare growth rates for fall and spring chinook reared in the Michigan and Oregon systems, and for summer steelhead reared in the Michigan system at Umatilla Hatchery.

7. Determine and compare fin condition, degree of descaling, degree of smolting, length, weight, and condition factor at release for fall and spring chinook reared in the Michigan and Oregon systems, and for summer steelhead reared in the Michigan system at Umatilla Hatchery.

8. Compare the physiological stress response of fall and spring chinook salmon reared in Michigan and Oregon systems at Umatilla Hatchery.

9. Compare the Na^+K^+ATPase activity of gill tissue from subyearling spring chinook salmon reared in Michigan and Oregon systems at Umatilla Hatchery.

10. Cold brand and release representative groups of fall chinook and subyearling spring chinook salmon from all Michigan and Oregon ponds for an evaluation of smolt migration performance.

11. Acquire recovery information and compare relative survival and migration characteristics to John Day Dam for fall and spring chinook salmon reared in the Michigan and Oregon systems.

12 Fin mark, coded-wire tag, and release representative groups of fall and subyearling spring chinook salmon from all Michigan and Oregon ponds to evaluate smolt-to-adult survival.

13. Fin mark, coded-wire tag, and release representative groups of summer steelhead to evaluate smolt-to-adult survival.

14. Fin mark and coded-wire tag representative groups of subyearling and yearling spring chinook at Umatilla Hatchery and yearling spring chinook at Bonneville Hatchery for the yearling and subyearling production evaluations.

15. Fin clip, fin clip and body tag, body tag, coded-wire tag plus fin clip and release replicate groups of fall chinook salmon to evaluate the effects of marking and tagging on smolt-to-adult survival.

16. Develop and implement statistical creel methods to estimate sport harvest of summer steelhead, spring chinook, and fall chinook.

17. Participate in the development of a water quality sampling and monitoring program in the Umatilla Basin.

18. Participate in planning the production and management activities of anadromous fish in the Umatilla River Basin.

19. For juvenile fish health monitoring, identify two series each of Michigan and Oregon raceways of each species and stock as index raceways. Use fish from these index raceways for monthly fish health monitoring activities.

20. Conduct monthly fish health examinations of five fresh dead or moribund fish from index raceways for *Renibacterium salmoninarum*, erythroctyic inclusion body syndrome (chinook only), gill and systemic bacteria, and external parasites. Conduct monthly examinations of five normal appearing grab-sampled fish from a lower raceway of each index series for *R. salmoninarum* and external parasites.

21. Conduct preliberation examinations on 30 fish from each raceway for *R. salmoninarum* and on 30 chinook from each raceway for erythrocytic inclusion body syndrome. Examine two fish from each lower raceway for external parasites and gill condition during preliberation examinations.

22. Collect gills at preliberation from 10 fish from a cross-section of upper, middle and lower Michigan raceways, and upper and lower Oregon raceways, for histological examination.

23. Conduct virological preliberation examinations on 30 fish each from a cross-section of Michigan and Oregon raceways. Assay samples of gill/kidney/spleen as five-fish pools by cell culture methods.

24. Using data obtained from monthly and preliberation fish health examinations, assess what effects differing rearing strategies and environments have on fish health.

25. Examine fish using appropriate diagnostic methods when unusual loss or behavior occurs. Implement therapeutic or prophylactic measures to control, moderate, or prevent disease outbreaks.

26. Monitor brood stocks used for Umatilla Hatchery production for *R. salmoninarum* and culturable viruses, and for erythrocytic inclusion body syndrome in chinook. Use weekly subsamples for large spawning populations.

27. Implement enzyme-linked immunosorbent assay (ELISA) technology for *R. salmoninarum* monitoring.

Accomplishments for FY 1992

We achieved all of our objectives in FY 1992 except two. We did not meet objective 11 because the juvenile migration data was received too late to be analyzed and included in this report. Objective 18, participating in the development of a water quality monitoring program for the Umatilla Basin, was not completed due to logistic restraints.

Findings in FY 1992

Size differences between fish reared in the Michigan and Oregon systems and between fish reared in different raceways within a system were evident during rearing and at release. In general, these differences were slight. However, spring chinook reared in the Oregon system averaged 4% longer and 11% heavier than spring chinook reared in the Michigan system. It is uncertain whether this difference is large enough to affect post-release growth or survival of Umatilla spring chinook.

Growth rates, food conversion ratios, and smolt condition of fall and spring chinook salmon were similar between fish reared in the Michigan and Oregon systems. There were considerable differences in the food conversion ratios, smolt condition, and pre-release size in steelhead reared in Michigan raceways at Umatilla Hatchery and steelhead reared in standard Oregon raceways at Irrigon Hatchery. Umatilla steelhead exhibited more prevalent and more severe fin erosion, less efficient food conversion, and were smaller at the time of pre-release sampling than steelhead at Irrigon Hatchery.

Gill Na+K+ATPase levels were used as a physiological index of smoltification for spring chinook salmon. Gill ATPase levels increased

significantly at release from the hatchery. We believe that these salmon were released in the initial stages of smoltification.

Plasma levels of cortisol and glucose were measured as routine indices of the physiological stress response in fall and spring chinook salmon. Levels of both hormones increased in response to a standardized stressor suggesting that the system salmon were reared in did not affect their ability to respond to stressors.

During the initial phases of rearing juvenile chinook salmon and steelhead at Umatilla Hatchery, an epizootic of bacterial cold water disease, caused by *Flexibacter psychrophilus* occurred in fall chinook salmon. Losses occurred in fish in both Michigan and Oregon raceways at a time when biologists were coded-wire tagging and fin clipping fish. *F. psychrophilus* was also the first fish pathogenic agent detected in fish (Umatilla summer steelhead) at Umatilla Hatchery. This bacterium was the most prevalent fish pathogen isolated during monthly monitoring.

Researchers detected a high prevalence of infectious hematopoietic necrosis virus in both Bonneville fall chinook and Carson spring chinook adults used as brood stock for Umatilla Hatchery. However, no evidence for transmission to their progeny was obtained during juvenile monthly or preliberation fish health monitoring.

Researchers detected *Renibacterium salmoninarum* antigen at low prevalences and low levels in juveniles of all three salmonid stocks reared at Umatilla in 1991-92. Enzyme-linked immunosorbent assay (ELISA) technology was implemented to monitor and evaluate Umatilla Hatchery stocks for this important salmonid pathogen. Because of the small size of the subyearling spring and fall chinook salmon reared at Umatilla Hatchery, unusually high dilutions of kidney tissue were required to obtain sufficient volumes for ELISA from individual fish. This may account, in part, for the low levels of antigen detected. Biologists are trying to resolve this problem.

No definitive differences in the occurrence or severity of infectious diseases could be discerned between fish in Oregon and Michigan raceways during the first months of rearing. If differences do occur, these may be more apparent in the yearling spring chinook, which will be in the hatchery environment far longer than subyearling populations.

Management Implications and Recommendations

1. Poor food conversion of summer steelhead reared in Michigan ponds in 1992 indicates poor performance of Umatilla stock summer steelhead in the hatchery. In addition, small size at release and high levels of severe fin erosion suggest that post-release performance and survival will be impaired in these fish. Consequently, we have recommended that the summer steelhead production be reduced from 210,000 to 150,000. This will reduce the average final rearing density from 6.8 lb/cu ft to 5.0 lb/cu. ft. of water. We anticipate that reduced rearing densities will result in better food conversion, larger size at release, and less fin erosion for the 1992 brood.

2. Tagging and marking of fall chinook took longer than anticipated and was completed just a few days prior to the target release date. In addition, the fall chinook had not reached desired size for release by the scheduled release date. These factors may have complicated post-release performance and survival of fall chinook had they been released on schedule. To prevent this problem from re-occurring next year, our recommendations are to revise the tagging scenario for 1992 brood fall chinook and to delay the target release date of fall chinook by two weeks to allow for recovery and additional growth after completing marking and tagging. This period of recovery and additional growth should ensure that fall chinook subyearlings are released with the best survival advantages.

3. Water shortages at Umatilla Hatchery have led to decreases in the production of spring and fall chinook salmon well below production levels necessary to achieve adult return goals for the Umatilla River. Given current available water conditions at Umatilla Hatchery, we recommended initiating a fall release for spring chinook salmon. Incorporating this production strategy for the 1992 brood will bring spring chinook salmon production to just above established goals without impacting current production at the hatchery.

UMATILLA HATCHERY MONITORING AND EVALUATION

INTRODUCTION

The Northwest Power Planning Council's Columbia River Basin Fish and Wildlife Program authorized construction of the Umatilla Hatchery in 1986. Measure 703 of the program amended the original authorization for the hatchery and specified evaluation of the Michigan type of rearing using oxygen supplementation to achieve production goals of 290,000 lb of steelhead (Oncorhynchus mykiss) and chinook salmon *(Oncorhynchus tshawytscha)*. The hatchery was completed in the fall of 1991. Justification for the hatchery, in part, was that it provided opportunity to develop considerable knowledge and understanding of new production and supplementation techniques. The use of the Michigan type of rearing at Umatilla Hatchery was selected because it could increase smolt production given the limited hatchery well water supply and would provide an opportunity to compare the Michigan type of rearing with the standard Oregon method. Results of testing the Michigan method of rearing will have systemwide application in the Columbia Basin.

The Umatilla Hatchery is the foundation for rehabilitating chinook salmon and enhancing summer steelhead in the Umatilla River (CTUIR and ODFW 1990) and is expected to contribute significantly to the Northwest Power Planning Council's goal of doubling salmonid production in the Columbia Basin. Hatchery production goals and a comprehensive plan for monitoring and evaluation are presented in the Umatilla Hatchery Master Plan (CTUIR and ODFW 1990). The Comprehensive Plan for Monitoring and Evaluation of Umatilla Hatchery (Carmichael 1990) was approved by the Northwest Power Planning Council as a critical part of the adaptive management process that guides the fisheries rehabilitation program in the Umatilla River. The adaptive management process uses monitoring and evaluation to increase knowledge about the uncertainties inherent in the fisheries rehabilitation program and will complement the developing systemwide monitoring and evaluation program.

The monitoring and evaluation goals are:

1. Provide information and recommendations for culture and release of hatchery fish, harvest regulations, and natural escapement that will lead to the accomplishment of long-term natural and hatchery production goals in the Umatilla River Basin in a manner consistent with provisions of the Council's Columbia River Basin Fish and Wildlife Program.

2. Assess the success of achieving the management objectives in the Umatilla River Basin that are presented in the Master Plan and the Comprehensive Rehabilitation Plan.

A substantial proportion of the production at Umatilla Hatchery will be produced in the "Michigan Type" oxygen supplementation system. This rearing system has not been thoroughly evaluated to determine the effects on smolt-to-adult survival. In addition, the rearing strategies proposed for spring chinook salmon are somewhat different than normal. The constant water temperature will provide growth conditions that should allow production of subyearling smolts at 15-20 fish/lb. Production of yearling smolts will require an unusually extensive period of incubation in chilled well water. The monitoring and evaluation program objectives for this report period were:

1. Determine to what extent the efficiency of producing adult fall chinook, spring chinook, and summer steelhead can be increased through the Michigan rearing method.

2. Monitor water quality parameters in a series of Michigan and Oregon raceways for each species reared.

3. Determine-and compare smolt migration performance and smolt to adult survival of subyearling and yearling spring chinook.

4. Document fish cultural and hatchery operational practices.

5. Identify and compare the effects of tagging and marking on smolt-to-adult survival of subyearling fall chinook smolts.

6. Coordinate in the development of a water quality sampling and monitoring program in the Umatilla River Basin.

7. Participate in planning and coordination activities associated with anadromous fish production, passage, monitoring, and evaluation in the Umatilla River Basin.

8. Monitor and evaluate the health of fish at Umatilla Hatchery.

Extensive background and justification for Umatilla Hatchery monitoring and evaluations is presented in Carmichael (1990). In this report, we present a review of our activities and findings for the Umatilla Hatchery Monitoring and Evaluation Project from 1 September 1991 to 30 October 1992. We have designed our program to include evaluation studies in the following categories: fish cultural practices, water quality monitoring, rearing performance and survival studies, spring chinook yearling and subyearling production evaluation, fall chinook marking and tagging evaluation, creel surveys, and planning and coordination.

STUDY SITE

The Umatilla fish hatchery is located approximately seven miles from the town of Irrigon, Oregon (Figure 1). The hatchery is operated under a cooperative agreement among the Oregon Department of Fish and Wildlife, the Confederated Tribes of the Umatilla Indian Reservation, the Bonneville Power Administration, the U.S. Fish and Wildlife Service, and the U.S. Army Corps of Engineers. A schematic diagram illustrating the pond configuration for the Umatilla Hatchery is displayed in Figure 2.

The Umatilla Hatchery was designed for production of salmonids in oxygen supplemented "Michigan" type raceways and in non-oxygen supplemented standard "Oregon" type raceways. Specific information about the hatchery is available in the Umatilla Hatchery Master Plan (CTUIR and ODFW 1990) and in the Environmental Assessment Report (Bonneville Power Administration 1987). The Michigan system consists of eight series of raceways with three raceways per series for a total of 24 raceways. Water flows from the upper raceway (A) to the middle raceway (5) and then to the lower raceway (C) within each series. Before the water enters each raceway, pure oxygen is supplemented through a

pipe injection system. Each Michigan raceway is 27.7 m long and 2.7 m wide with a water flow of approximately 2,839-3,520 Lpm. Water depth was kept at 76 cm during rearing. In each raceway there are nine baffles placed 10-11 ft apart to promote water movement across the bottom and aid in raceway cleaning. In addition, Michigan raceways were cleaned by vacuuming at the outflow screen one to three times per day. Due to water availability problems, not all Michigan raceways were operated in 1992.

The Oregon system at Umatilla Hatchery consists of five series of raceways with two raceways per series for a total of 10 Oregon raceways. Water flows from the upper raceway (A) to the lower raceway (B). Each Oregon raceway is 27.7 m long and 6.1 m wide and no cleaning baffles are present. Oregon raceways were vacuumed daily at the outflow screen and broom cleaned once per week. Water depth was kept at 107 cm during rearing. All 10 Oregon raceways were used in 1992.

For the summer steelhead, comparisons were made using Wallowa stock that were raised in the Irrigon Hatchery. All raceways at the Irrigon site were Oregon style, but were slightly larger at 30.5 m long and 6.1 m wide. Water height was kept at 117 cm. Physical characteristics of each style raceway are presented in Table 1.

The Umatilla River and tributaries are located in Umatilla, Morrow, and Union counties, Oregon (Figure 1). Tests of fall and spring chinook salmon smolt condition were conducted at the Barnhart (Umatilla River mile 42.5) and Fred Grey release sites (Umatilla River mile 80) respectively.

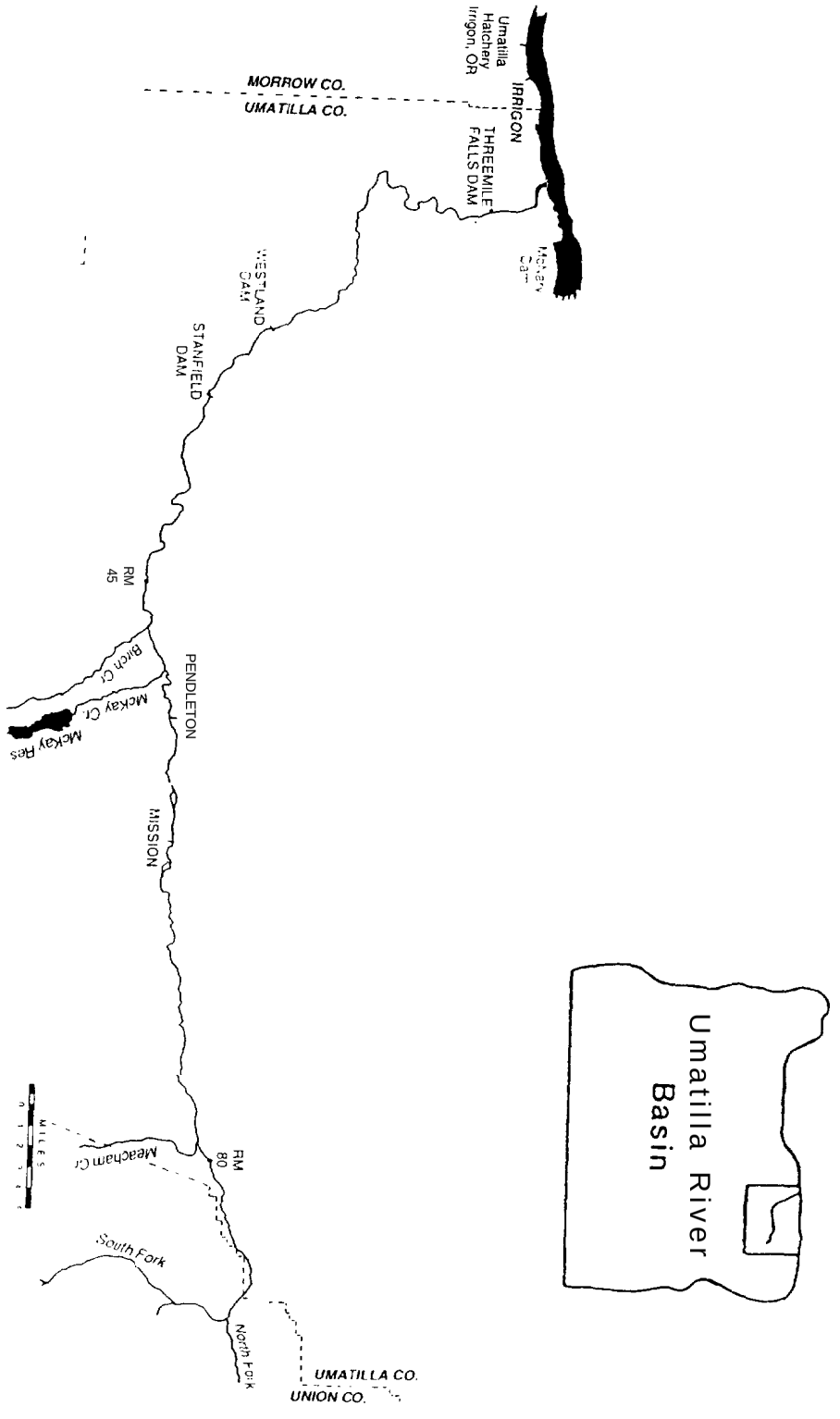

Figure 1. Location map, Umatilla River Basin

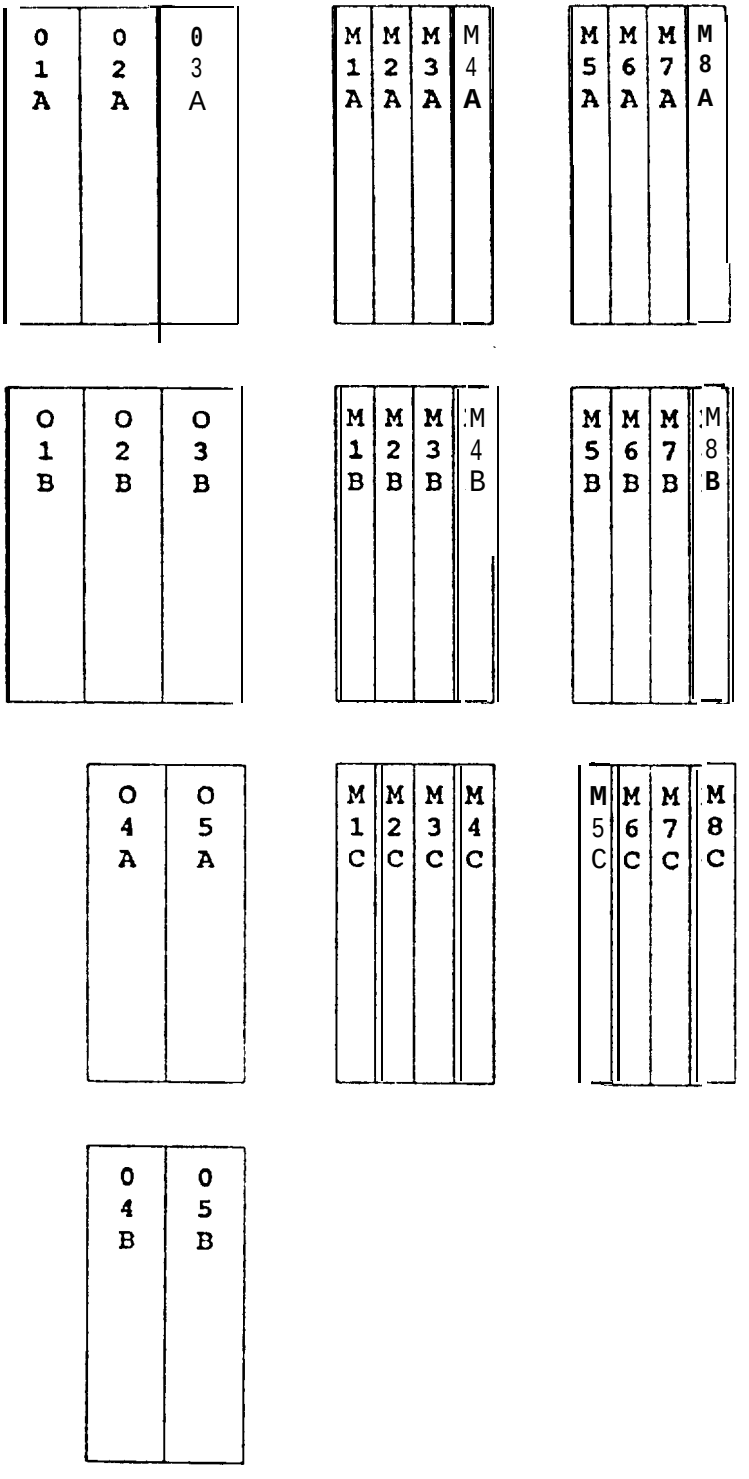

Figure 2. Pond schematic for Umatilla Hatchery (0 = Oregon system, M = Michigan system, number = raceway, A = first pass, B = second pass, C = third pass).

Table 1. Physical characteristics of the Oregon and Michigan raceways located at Umatilla and Irrigon Hatcheries, Irrigon, Oregon.

System	Location	Length (m)	Width (m)	Water Depth (cm)	Volume (m^3)	Flow (Lpm)
Michigan	Umatilla	27.7	2.7	76	58	2839[a]
Oregon	Umatilla	27.7	6.1	107	176	4731
Oregon	Irrigon	30.5	6.1	117	215	5791

a Summer steelhead were reared in Michigan ponds with a flow of 3520 Lpm.

METHODS

Fish Cultural Practices

We monitored fish cultural and hatchery operational practices at Umatilla Hatchery. Hatchery records were used to determine the number of eggs taken, egg mortality, fry mortality, and smolts released. Egg-to-smolt survival rates were calculated for fall chinook, spring chinook, and summer steelhead. The number of fish released, the size of fish released for major production groups, and the location of release also were determined from hatchery records.

Water Quality Monitoring

We monitored water quality in an index series of Michigan and Oregon raceways in which fall and spring chinook salmon were reared and in a series of Michigan raceways in which summer steelhead were reared. Measurements were taken between 1100-1300 h on each sampling day to minimize disturbance from hatchery operations. Samples were collected weekly from mid-February to mid-May 1992. Parameters measured at the head and tail of each raceway included; water temperature ("C), total gas pressure (mm Hg), partial pressure of oxygen (mm Hg), partial pressure of nitrogen (mm Hg), and pH. Parts per million of 02 were calculated from the partial pressure of 02, pH, and temperature data. We used a Model TBO-F, Common Sensing meter to monitor gas pressure and a portable meter to determine pH. Both meters were calibrated immediately prior to each sampling period.

We determined total alkalinity and unionized ammonia from water samples collected biweekly at the tail of each raceway. Samples were collected between 0700 and 0800 h to minimize impact from daily feeding activities and were sent immediately for analysis. We used the titration method (Standard Methods 1980) to determine the alkalinity (mg/l CaC03). Total ammonia concentrations were determined by an independent testing laboratory using the

phenate method. The proportion of unionized ammonia was calculated from total ammonia, temperature, and pH.

Rearing Performance and Survival Studies

Fall Chinook Salmon

Rearing Performance: To evaluate rearing performance, mean length and weight were determined, and condition factor, growth rates, and food conversion ratios were calculated once per month from mid-February 1992 to pre-release in May 1992. During monthly sampling we measured 100 fork lengths and 50 weights from a sample of fish out of each raceway. Length and weight data were used to calculate the condition factor (weight/length^3*100,000; Nielsen et al. 1983). Growth rates were determined by plotting mean monthly mean weight over time.

We calculated the mean food conversion ratio for fall chinook in the Oregon and Michigan systems from food conversion ratios for each raceway. Ratios were determined only after fish were split into their final raceway. The total weight gained by a group of fish in each raceway was calculated by subtracting the total weight at the start of the time period from the final weight at release. To estimate the food conversion ratio, we divided the total pounds of feed fed by the pounds of weight gained.

Smolt Condition: We examined smolts at pre-release to determine their general condition. Measurements included fork length (mm), weight (g), condition factor, smolt stage, and the amount of descaling. The pre-release sample was taken 7-10 days prior to liberation from the hatchery. At pre-release we measured 300 fork lengths and weighed 200 fish from each raceway. The length and weight data were used to calculate condition factors as described above.

We documented the smolt stage from a sample of 200 fish in each raceway. To evaluate smoltification, we examined both sides of the fish and classified them as smolts if they were silvery and no parr marks were present. Fish with discernible, yet not a complete set of parr marks, were classified as intermediate smolts while fish with full parr marks were noted as Parr.

To determine the extent of descaling, we examined 200 fish in each raceway. We recorded fish as undamaged if the cumulative scale loss was less than 3% on both sides of the body. If cumulative scale loss exceeded 3% on one side of the body, but was less than 16%, we listed the fish as partially descaled. Descaled fish were those that had a cumulative scale loss equal to or exceeding 20% on one side.

We evaluated and compared the physiological stress response of fall chinook reared in Michigan and Oregon systems. Physiological indicators of stress were determined for control and stressed fish, both at the hatchery prior to release and at the release site after transport from the hatchery. Plasma levels of cortisol and glucose were assayed for 20 salmon from each raceway. Ten treatment fish were subjected to a standardized stress by

removing them from a raceway at the hatchery or from the stocking truck at the release site and holding them out of water in a 0.1 sq m net pen for 30 seconds. The net pen containing fish was returned to the raceway or placed in the Umatilla River for one hour. After one hour the fish were anesthetized with a lethal dose of tri-methylcaine sulfate (MS--222). After anesthetization the caudal fin of each fish was severed and blood samples were collected in heparinized capillary tubes. The tubes were sealed, placed on ice, and transported to the laboratory. The tubes were spun with a microcentrifuge for two minutes to separate out the plasma from the red blood cells. The plasma was transferred to storage tubes, transported on dry ice, and stored in a supercool freezer (-80°C). These samples were analyzed by an independent laboratory for plasma concentrations of cortisol and glucose.

Smolt Migration Performance: In the future, we will compare the smolt migration success, migration rate, and the duration of migration for fall chinook salmon raised in the Oregon and Michigan systems. To identify fish, we freeze-branded approximately 10,000 fall chinook salmon from each of the Oregon and Michigan raceways. The brands were approved by and coordinated with the National Marine Fisheries Service and the Fish Passage Center. Each raceway was assigned a unique brand. The brands were supercooled with liquid nitrogen and were applied to a fish for one second to leave a mark. To determine brand readability, we subsampled fish from each raceway during pre-release sampling. This information, along with total numbers branded, was sent to the personnel at the Fish Passage Center in Portland, Oregon, who monitored downstream fish passage and recorded the numbers of branded fish observed at mainstem Columbia River dams. Data from the Fish Passage Center will be analyzed when it is received and will be included in future reports.

Smolt-to-Adult Survival: In the future, we will compare the percentage of fall chinook surviving from the smolt to the adult stage between Michigan and Oregon raceways. To identify fish from each raceway, approximately 30,000 fall chinook were marked with coded-wire tags and adipose fin clipped (AD+CWT). To assess tag loss, a subsample of 300-400 fish was checked for tag retention a minimum of 14 days after tagging.

Spring Chinook Salmon

Rearing Performance: We monitored spring chinook salmon rearing performance in the same manner as described for fall chinook salmon.

Smolt Condition: We monitored spring chinook salmon smolt condition in the same manner as for fall chinook salmon. In addition, gill ATPase was measured as a physiological index of smoltification. Gill samples were obtained from spring chinook salmon at approximately 45, 30, and 15 days prior to release, and at the time of release. Gill filaments were removed by cutting them from the four left gill arches. Occasionally, it was necessary to remove filaments from right arches. Once cut, the gill filaments were placed in a fixative (SE1 buffer), transported on dry ice, and stored in a supercool freezer (-80°C). These samples were analyzed by an independent laboratory for Na^+K^+ATPase (μmoles P/h/mg of protein).

Smolt Migration Performance: Smolt migration success, migration rate, and the duration of migration will be compared for spring chinook salmon in the same manner as for fall chinook salmon.

Smolt-to-Adult Survival: In the future we will compare the percentage of spring chinook surviving from the smolt to the adult stage between Michigan and Oregon raceways. To identify fish from each raceway, approximately 50,000 spring chinook were marked with AD+CWT. To assess tag loss, a subsample of 300-400 fish was checked for tag retention a minimum of 14 days after tagging.

Summer Steelhead

Rearing Performance: Summer steelhead rearing performance was monitored in the same manner as for fall and spring chinook salmon.

Smolt Condition: Smolt condition for summer steelhead was evaluated in the same manner as for fall and spring chinook salmon with the following modifications. The food conversion ratio for Wallowa stock steelhead in Oregon raceways at the Irrigon Hatchery was generated from data on 30 first and second pass raceways; therefore, a mean value with associated statistics could not be computed. We evaluated fin erosion on summer steelhead by examining all fins on approximately 200 fish per raceway. Fin erosion was divided into four categories (Figure 3). Good fins had sharp edges and points. Slightly eroded fins were those with rough edges or rounded points. Raw fins were approximately 50% eroded with significant fin loss. Severely eroded fins were those with less than 25% of the fin remaining and few or no fin rays visible.

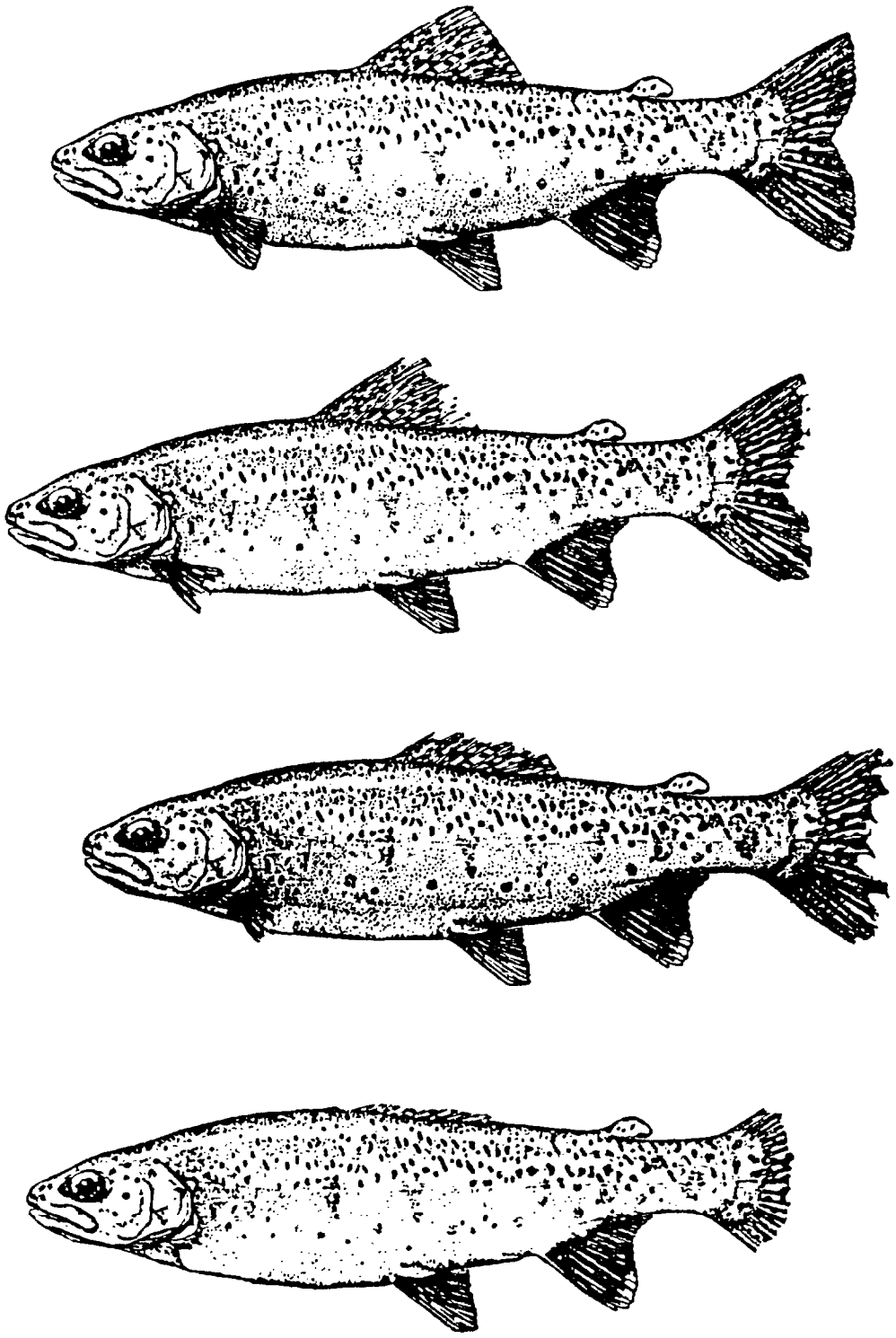

Figure 3. Criteria for evaluating fin erosion on summer steelhead.

Spring Chinook Subyearling and Yearling Production Evaluation

In the future we will compare the percentage of spring chinook smolts surviving to the adult stage between groups of yearlings reared at Umatilla and Bonneville hatcheries and subyearlings reared at Umatilla Hatchery. To identify fish from each raceway, we marked approximately 30,000 yearlings in each raceway with ADtCWT. To assure accuracy of tagging, a subsample of 300-400 fish from each raceway was checked for tag retention a minimum of 14 days after tagging. The subyearling groups to be used for this evaluation are also being used to evaluate rearing spring chinook in the Michigan and Oregon systems. The tagging operations for the subyearling chinook were described previously under spring chinook smolt-to-adult survival.

Effects of Tagging and Marking on Subyearling Fall Chinook Salmon

To evaluate the effects of marking on survival of fall chinook salmon, all Umatilla fall chinook were marked with fin marks, blank-wire body tags or coded-wire tags. Replicate groups of 70,000 salmon were marked as follows: left ventral clip (LV), left ventral clip plus body tag (LV-BT), body tag only (BT), and adipose (AD)-right ventral (RV) plus CWT. We will compare smolt-to-adult return rates based on future recoveries at Three Mile Dam and other collection sites in the Columbia River Basin (Figure 1). Effects of different marks will be based on the following comparisons:

1. BT versus LV.
2. BT-LV versus BT to evaluate the effect of a ventral clip.
3. BT-LV versus LV to evaluate the effect of the body tag.
4. AD-LV+CWT versus LV to evaluate the effect of the adipose clip and coded-wire tag.

Tag retention checks were conducted on both coded-wire tagged and body tagged fish a minimum of 14 days after tagging.

Creel Survey

We developed a creel survey to assess the annual recreational fish harvest of chinook salmon and summer steelhead in the Umatilla River. This survey will assist managers in determining if harvest objectives are being achieved. In developing our creel methods, we reviewed methods of other creel programs and statistical analyses.

Statistical Analyses

The majority of tests comparing parameters between Michigan and Oregon systems and between passes within each system were analyzed using T-tests and analysis of variance (ANOVA). When applicable we used a nested ANOVA to separate sources of variation within the Michigan and Oregon systems. A maximum of three nesting levels were used and were as follows:

First level - SYSTEM (e.g. Michigan Oregon)
Second level- RACEWAY (e.g. M2 03)
Third level - PASS (eg A, B, C)

The analysis of the stress response required an additional first level factor (treatment) and a treatment-by-system interaction factor to test for

differences between Michigan and Oregon systems. The analysis of gill ATPase in spring chinook also included a date effect. For all tests within the Michigan system, the ANOVA model included a treatment effect, a pass effect, and a treatment-by-raceway interaction factor. All planned comparisons of differences between means were made using the Sidak technique (Sokal and Rohlf 1981) at an alpha level = 0.05. Growth rates were tested by comparing the slopes of regression lines computed from monthly growth information (Sokal and Rohl f 1981). Condition factors and the proportion of descaled and partially descaled fish were tested using the Kruskall-Wallis and Wilcoxon non-parametric analyses. Differences between pairs of means were tested by the Wilcoxon method. For tests comparing the Oregon and Michigan systems, we included only A and B raceways. Tests designed to examine differences within the Michigan system included A, B, and C raceways.

RESULTS

Fish Cultural Practices

Fall Chinook Salmon

The egg sources for 1991 brood fall chinook salmon were Upriver Bright stock from Bonneville Hatchery and the Umatilla River. Eggs were incubated at both Bonneville and Umatilla hatcheries at 50-52 ^{O}F. Approximately 600,000 green eggs from the Umatilla River source were taken from 6-26 November and were immediately transferred to Umatilla Hatchery. Approximately 2.87 million eyed eggs were transferred from Bonneville to Umatilla Hatchery from 9-23 December. Approximately 2.786 million swim-up fry (from Bonneville stock) were ponded into four Oregon raceways in February at 950 fish/lb. Due to water limitations at Umatilla Hatchery, all of the fry resulting from brood collected at the Umatilla River were transferred to Irrigon Hatchery. Bonneville source fish were subsequently split into six Michigan and four Oregon raceways when they reached 100 fish/lb in early April. To standardize donor parentage for each treatment and control group, fish were split so that each Michigan and Oregon raceway received equal proportions of fry from all egg-takes. Final ponding splits had been completed by 3 April, but fish were moved once more for tagging, marking, and branding. Rearing conditions for the fall chinook are described in Table 2. All Upriver Bright stock fall chinook salmon were released between 18 and 20 May 1992 at 62 fish/lb. Additional release information can be found in Table 3. Egg-to-smolt survival estimates can be found in Table 4.

Spring Chinook Salmon

1991 Brood Subyearlings: The brood source for spring chinook salmon was Carson stock from the Carson National Fish Hatchery in Washington. Approximately 1.5 million green eggs were transferred to Oxbow hatchery where they were incubated at 52-53^{O}F. Eyed eggs were transferred from Oxbow to Umatilla Hatchery between 23 September and 1 October. Approximately 1.3 million fry were ponded into Canadian troughs inside the incubation room in late December 1991. Fish were split into two Oregon raceways at the start of

January at 1,375 fish/lb and then into six additional Michigan raceways at the end of January at 240 fish/lb. Final splits were completed by the end of March. Fish were ponded and split so that each Michigan and Oregon raceway received equal proportions of fry from all egg-takes at the Carson Hatchery. This ensured that the donor parentage for each treatment and control group was equal. Rearing conditions for spring chinook are described in Table 2. Spring chinook subyearlings were liberated from 4 May to 13 May, 1992, at approximately 35 fish/lb. Additional release information can be found in Table 3. Egg-to-smolt survival estimates can be found in Table 4.

1991 Brood Yearlings: The brood source for the yearling program was also Carson stock. Approximately 380,000 green eggs were received and incubated at 42.5°F for the first seven days then lowered to 38°F for 300 days. Approximately 327,000 fry were ponded into indoor Canadian troughs in May 1992. Fish were moved to one Oreqon pond in June when they reached 500/lb. In early July, fish were split into 2'Oregon ponds when they reached Z00/lb. Approximately 106,000 of these fish will be released in November of 1992, the remainder will be released in the spring of 1993.

Summer Steelhead

The brood stock for summer steelhead were Umatilla River stock. When steelhead eggs were taken in 1991, construction at Umatilla Hatchery was not complete. Therefore, approximately 340,000 green eggs were taken to Irrigon Hatchery for incubation at 52°F. Approximately 270,000 fry were ponded into indoor, circular tanks at swim-up. Fish were moved outside in July at 450 fish/lb. Steelhead were adipose clipped and ponded into standard raceways in September. They were graded, transferred to Umatilla Hatchery, and ponded into three Michigan raceways (M5A, M5B, and M5C) in November 1991 at 83.5 fish/lb, 48.9 fish/lb, and 27.9 fish/lb, respectively. Rearing conditions for spring chinook are described in Table 2. Fish from raceway M5C were moved to the Bonifer Springs and Minthorn Springs acclimation sites on 12 March 1992. Fish from raceways M5A and M5B were released from 29 April to 1 May 1992 in Meacham Creek at approximately 5 fish/lb. Additional release information can be found in Table 3. Egg-to-smolt survival estimates can be found in Table 4.

Table 2. Rearing conditions for 1991 brood fall and spring chinook salmon and 1991 brood summer steelhead in Oregon and Michigan raceways at Umatilla Hatchery.

Race-species	System	Density (lb/ft^3)	Loading Factor (lb/gal/min)
Fall Chinook	Michigan	2.0-2.4	5.4-6.6
	Oregon	0.5-0.7	2.6-3.5
Spring Chinook[a]	Michigan	1.2-1.4	3.4-3.9
	Oregon	0.3-0.5	1.6-2.4
Summer Steelhead	Michigan	5.4-6.7	11.8-14.6
	Irrigon-standard	1.3	6.6

a 1991 brood subyearlings

Table 3. 1992 release information for salmon and steelhead reared at Umatilla Hatchery and released into the Umatilla River.

Race-species, rearing system	Date released	Number released	Mean weight (fish/lb)	Release location	N	Mean fork (mm)
Fall Chinook:						
Michigan	18-19 May	1,736,403	63.0	UmR. mi 80	1464	83.8
	14 Apr-6 May	2,403[a]		UmR. mi 3	349	65.1
Oregon	18-19 May	942,196	65.2	UmR. mi 42.5	1274	81.8
Spring Chinook:						
Michigan	11-13 May	636,393	35.4	UmR. mi 80	1210	98.3
Oregon	11-13 May	319,359	31.9		1250	104.1
Steelhead:						
Michigan	29 Mar	47,458	5.8[b]	Minthorn Acclimation Facility	300	196.9[b]
	29 Mar	19,977	5.8[b]	Bonifer Acclimation Facility	300	198.4[b]
	29 Apr-1 May	131,969	5.0	Meacham Creek	651	197.1
	7-9 Apr	4,507[a]	5.8	UmR. mi 3	1265	193.1

a Released for juvenile passage evaluation study.

b Values are estimated from pre-release sampling conducted by CTUIR at the Bonifer and Minthorn acclimation facilities.

Table 4. Egg-take and survival of salmon and steelhead reared at Umatilla Hatchery, 1991 brood year.

Race-species, source	Number of eggs taken	Number of eggs received	Egg loss (%)	Egg-to-fry survival (%)	Egg-to-smolt survival (%>
Fall Chinook:					
Bonneville[a]	3,159,310	2,872,000	10.0	88.2	84.9
Umatilla[b]	601,548	- - -	9.9	85.4	84.8
Spring Chinook:					
Carson[C]	1,555,040	1,330,465	14.4	83.3	80.4
Summer Steelhead					
Umatilla d	340,674	--	20.0	78.4	66.6

[a] *Eggs were incubated at Bonneville Hatchery. Survival estimate does not include 2,403 parr removed for passage evaluation.*

[b] *Survival estimate does not include 5,401 smolts removed for passage evaluation.*

[c] *Eggs* were *incubated at Oxbow and Carson hatcheries. 1991 brood spring chinook yearlings will be included in FY93 Annual Report.*

[d] *Survival estimate does not include 5,443 smolts removed for passage evaluation nor 27,860 that were graded off.*

Water Quality Monitoring

Comparisons of Oregon and Michigan Systems

Temperature: Water quality data for Michigan and Oregon raceways are presented in Table 5. Water temperature measurements at the head and tail of the raceways were similar between systems, averaging 11.5-12°C. The only significant (Pt0.004) temperature difference observed was a 0.5°C difference between the Oregon and Michigan systems in fall chinook raceways.

pH: pH measurements at the head and tail of Michigan and Oregon raceways generally fell within the range of 7.0-8.0. Overall, pH levels in Oregon system were greater ($P \leq 0.05$) than the pH in Michigan system, although these differences were slight.

Oxygen, Nitrogen, and Total Gas Pressure: Mean partial pressures for oxygen (02), nitrogen (N_2), and means for total pressure were different between the Michigan and Oregon systems. In spring and fall chinook salmon raceways, the mean partial pressure of N_2 (head and tail) and total pressure

(tail) were significantly greater ($P<0.0012$) in Oregon raceways. As expected, oxygen levels in general were greater in the Michigan system ($P \leq 0.008$).

Mean O_2 levels typically declined 1 ppm from the head to the tail of the spring and fall chinook raceways in both rearing systems. Within the Oregon system, the mean tail oxygen levels dropped below the recommended level of 6.5 ppm (Figure 4). Several declines of 02 levels below recommended criteria also were observed in the Michigan summer steelhead raceways with levels as low as 6 ppm (Figure 5).

Alkalinity: No significant differences ($P>0.29$) in alkalinity values were found between Michigan and Oregon raceways. Alkalinity was stable throughout the duration of our monitoring, averaging 144 mg $CaCO_3/L$.

Unionized Ammonia: No significant differences ($P>0.38$) among mean unionized ammonia levels were found between the Michigan and Oregon systems. Mean NH_3 levels ranged from 0.50 to 4.5 $\mu g/L$ for all raceways.

Table 5. Water quality comparisons of Oregon and Michigan systems. Means are combined values for first and second pass raceways (* = significant difference $P \leq 0.05$).

Race-species, parameter measured	Mean parameter value (N) Oregon	Michigan	T-test
Fall Chinook:			
Temperature Head ("C)	**11.5 (22)**	11.9 (6)	*
Temperature Tail ("C)	**11.6 (22)**	11.9 (6)	*
pH Head	7.7 (22)	7.7 (6)	ns
pH Tail	7.7 (22)	7.5 (6)	*
Oxygen Head (ppm)	10.1 (22)	11.1 (6)	*
Oxygen Tail (ppm)	9.3 (22)	10.1 (6)	ns
Nitrogen Head (mmHg)	607 (22)	566 (6)	*
Nitrogen Tail (mmHg)	611 (22)	570 (6)	*
Total Pressure-Head (mmHg)	751 (22)	748 (6)	ns
Total Pressure-Tail (mmHg)	737 (22)	707 (6)	*
unionized ammonia ($\mu g/l$)	**1.55 (10)**	0.85 (2)	ns
alkalinity (mg/l CaC03)	**144 (10)**	144 (2)	ns
Spring Chinook:			
Temperature Head ("C)	11.9 (19)	**11.5 (22)**	ns
Temperature Tail ("C)	11.6 (19)	**11.6 (22)**	ns
pH Head	7.8 (19)	7.7 (22)	*
pH Tail	7.8 (19)	7.7 (22)	*
Oxygen Head (ppm)	9.8 (19)	12.5 (22)	*
Oxygen Tail (ppm)	8.6 (19)	9.4 (22)	*
Nitrogen Head (mmHg)	607 (19)	592 (22)	*
Nitrogen Tail (mmHg)	613 (19)	592 (22)	*
Total Pressure-Head (mmHg)	756 (19)	754 (22)	ns
Total Pressure-Tail (mmHg)	751 (19)	740 (22)	*
unionized ammonia ($\mu g/l$)	1.51 (9)	1.65 (10)	ns
alkalinity (mg/l CaC03)	145 (9)	143 (10)	ns
Summer Steelhead:			
Temperature Head ("C)	-	**11.5 (18)**	-
Temperature Tail ("C)		**11.5 (18)**	-
pH Head		7.7 (18)	-
pH Tail	-	7.4 (18)	-
Oxygen Head (ppm)	-	14.1 (18)	-
Oxygen Tail (ppm)	-	9.4 (18)	-
Nitrogen Head (mmHg)	-	549 (18)	-
Nitrogen Tail (mmHg)	-	557 (18)	-
Total Pressure-Head (mmHg)		754 (18)	-
Total Pressure-Tail (mmHg)		681 (18)	-
unionized ammonia ($\mu g/l$)		1.38 (8)	-
alkalinity (mg/l CaC03)	-	143 (8)	-

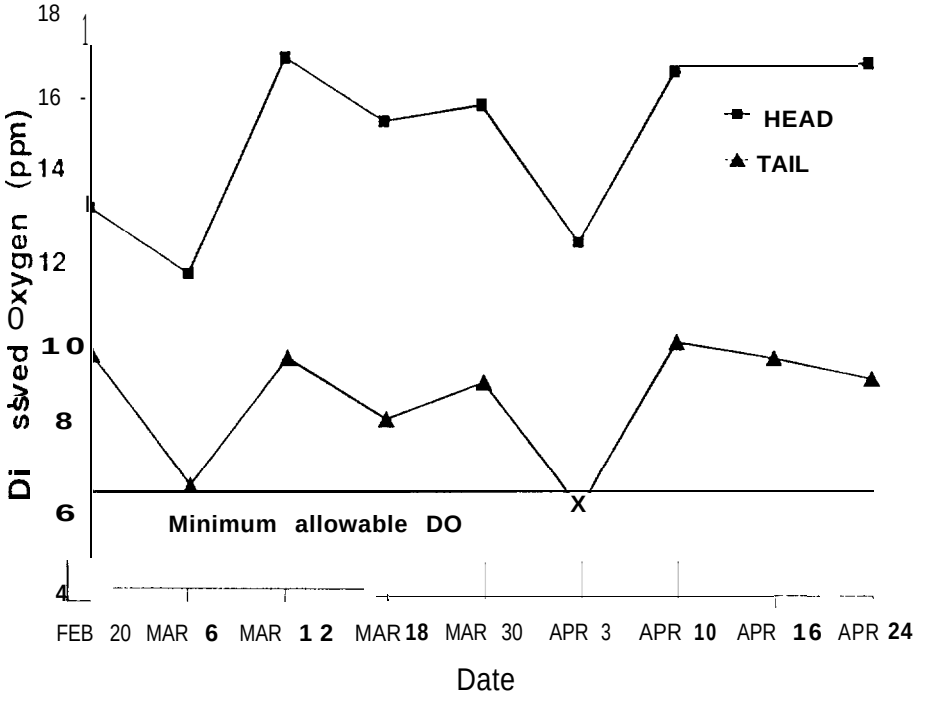

Figure 4. Dissolved oxygen levels at the head and tail of a second pass summer steelhhead Michigan raceway at Umatilla Hatchery, 1992.

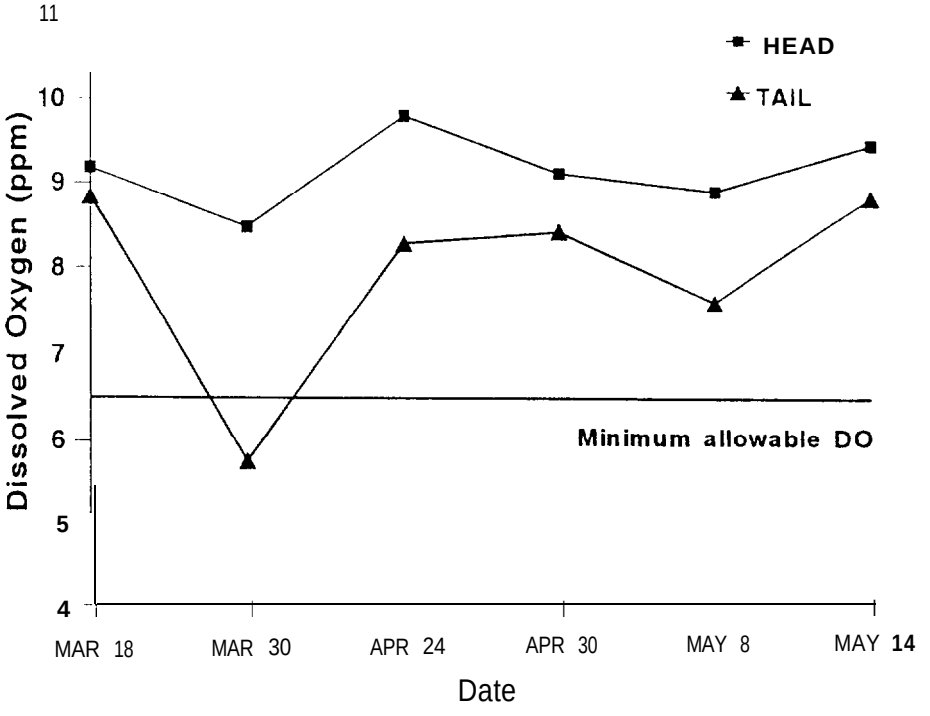

Figure 5. Dissolved oxygen levels at the head and tail of a second pass fall chinook salmon Oregon raceway at Umatilla Hatchery, 1992.

Within Michigan System Comparisons

Temperature: Water quality data for first, second, and third pass Michigan raceways are presented in Table 6. Weekly measurements during sampling varied from 11.1 to 12.4 ^{o}C. Although there was a significant temperature difference (Pt0.02) between measurements taken at the head of steelhead first and second pass raceways, no trend was observed that indicates a pass effect on water temperature.

pH: Within the Michigan system, mean pH values ranged from a low of 7.29 to a maximum of 7.85. Significant differences ($P<0.03$) were evident for all head and tail measurements except in the tail of spring chinook raceways. There was a gradual decline in pH at both the head and tail of most raceways as water moved to second and third pass raceways. The maximum change found was a 0.45 decrease from the head of the first to the head of the third pass summer steelhead raceway.

Oxygen, Nitrogen, and Total Gas Pressure: Significant differences ($P\leq0.04$) were observed for mean 02 partial pressure at the heads of first, second, and third pass spring chinook and summer steelhead raceways. However, no differences were observed between passes for mean 02 partial pressure at the tail of the raceways. On several occasions, 02 levels at the tail of Michigan raceways fell below the targeted 6.5 ppm (Figures 4 and 5).

Means of N2 partial pressure were significantly different ($P\leq0.003$) in the heads and tails of spring chinook and summer steelhead raceways, but not in fall chinook raceways. Means of total pressure (head) between passes of fall and spring chinook salmon raceways were similar. However, mean total pressure in the first pass summer steelhead raceway was significantly greater than mean pressure in head of second or third pass raceways. The mean total gas pressure in the tail of raceways declined significantly ($P\leq0.046$) from first to third passes for all species.

Alkalinity: No significant differences ($P>0.57$) for alkalinity were found between Michigan passes. Values ranged from 142 to 145 $CaCO_3/L$.

Unionized Ammonia: No significant differences ($P>0.05$) were found between passes. Mean NH3 levels ranged from 0.41 to 2.04 $\mu g/L$.

Table 6. Water quality comparisons between Michigan first, second, and third pass raceways. Different letters indicate significance at P0<.05.

Race-species, parameter measured	N	Mean parameter value 1st pass	2nd pass	3rd pass
Fall chinook:				
Temperature Head ("C)	3	12.0	11.8	12.0
Temperature Tail ("C)	3	11.9	11.9	12.2
pH Head	3	7.76 a	7.54 b	7.42 c
pH Tail	3	7.59 a	7.43 b	7.29 c
Oxygen Head (ppm)	3	11.8	11.6	12.3
Oxygen Tail (ppm)	3	9.3	9.4	9.3
Nitrogen Head (mmHg)	3	579	552	544
Nitrogen Tail (mmHg)	3	580	560	552
Total pressure-Head (mmHg)	3	752	743	732
Total pressure-Tail (mmHg)	3	717 a	698 ab	688 b
unionized ammonia (µg/l)	1	0.70	1.00	1.50
alkalinity (mg/l CaC03)	1	145	143	144
Spring Chinook:				
Temperature Head ("C)	11	11.5	11.5	11.7
Temperature Tail ("C)	11	11.5	11.7	11.8
pH Head	11	7.76 a	7.73 ab	7.66 b
pH Tail	11	7.71	7.66	7.60
Oxygen Head (ppm)	11	10.8 b	11.6 ab	12.3 a
Oxygen Tail (ppm)	11	10.0	10.5	10.8
Nitrogen Head (mmHg)	11	601 a	584 b	571 b
Nitrogen Tail (mmHg)	11	602 a	581 b	573 b
Total pressure-Head (mmHg)	11	756	753	750
Total pressure-Tail (mmHg)	11	745 a	735 ab	731 b
unionized ammonia (µg/l)	5	1.28	2.02	2.04
alkalinity (mg/l CaC03)	5	144	142	144
Summer Steelhead:				
Temperature Head ("C)	9(3)	11.7 a	11.4 b	11.6 ab
Temperature Tail ("C)	9(2)	11.4.	11.5	11.8
pH Head	9(3)	7.85 a	7.55 b	7.40 b
pH Tail	9(2)	7.52 a	7.35 b	7.35 ab
Oxygen Head (ppm)	9(3)	13.3	15.0	15.3
Oxygen Tail (ppm)	9(2)	8.4	8.7	8.8
Nitrogen Head (mmHg)	9(3)	571 a	527 b	507 b
Nitrogen Tail (mmHg)	9(2)	577 a	537b	538 b
Total pressure-Head (mmHg)	9(3)	764 a	744b	742 b
Total pressure-Head (mmHg)	9(2)	699 a	644b	668 ab
unionized ammonia (µg/l)	4(1)	1.38	3.38	0.41
alkalinity (mg/l CaC03)	4(1)	144	143	144

Rearing Performance and Survival Studies

Fall Chinook Salmon

Rearing Performance: Due to ponding restrictions, comparisons between Michigan and Oregon systems could only be made for the monthly sample in April and pre-release sample in May. Although monthly measurements of length, weight, and condition factor during rearing showed differences between systems, most differences were small (Table 7). In April the only significant size difference observed was that fall chinook reared in Michigan raceways were significantly longer (2%; $P \leq 0.0001$) than those reared in Oregon raceways.

Analysis of raceways within the Oregon system demonstrated that mean lengths and weights were similar among raceways when sampled in March (Table 8). However, in April fish raised in second pass Oregon raceways were significantly longer (6%; $P<0.0001$), and heavier (9%; $P \leq 0.01$) and had a lower condition factor ($P<0.02$) than fish raised in first pass raceways. Within the Michigan system there was a significant decline in lengths (2%; $P \leq 0.0001$) and weights (1%; $P \leq 0.0001$) from third and second to first pass raceways in April (Table 8). There was no significant difference between raceways for condition factor ($P>0.36$).

Growth rates after final splitting could only be tracked for 40 days. The slopes of regression lines for weight gain between Michigan and Oregon system fish were greater than zero ($P>0.05$), but they were not significantly different ($P \geq 0.05$) from each other (Figure 6). The mean food conversions were similar between rearing systems and within the Michigan system.

Table 7. Mean monthly and pre-release comparisons of length, weight, and condition factor for fall chinook salmon reared in Oregon and Michigan systems. Letters indicate statistical grouping based on Sidak's multiple comparison test. Means without letters are not significantly different at $P \geq 0.05$.

Sample, system	Length(mm) N	Length(mm) Mean(SE)	Group	Weight(g) N	Weight(g) Mean(SE)	Condition factor N	Condition factor Mean(SE)	Group
April:								
Oregon	439	72.6(0.27)	a	200	5.0(0.08)	200	1.24(0.007)	
Michigan	493	74.0(0.23)	b	202	5.1(0.08)	202	1.25(0.006)	
Pre-release:								
Oregon	1274	82.6(0.18)	c	400	7.0(0.08)	400	1.21(0.004)	c
Michigan	1464	83.5(0.16)	d	440	7.0(0.08)	440	1.17(0.004)	d

Table 8. Mean monthly and pre-release comparisons of length, weight, and condition factor for fall chinook salmon reared in first and second pass Oregon raceways and in first, second, and third pass Michigan raceways. Letters indicate groupings based on Sidak's multiple comparison test. Means without letters or means with the same letter are not significantly different P≥0.05.

Sample, raceway position	Lensth (mm) N	Mean(SE)	Group	Weight (g) N	Mean(SE)	Group	Condition Factor N	Mean(SE)	Group
Oregon Raceways									
March:									
1st Pass	**220**	**59.7(0.26)**		100	2.6(0.04)		100	**1.21(0.011)**	
2nd Pass	**223**	**59.8(0.25)**		106	2.7(0.05)		**106**	**1.25(0.011)**	
April:									
1st **Pass**	**230**	70.7(0.37)	a	100	4.8(0.13)	a	100	1.26(0.012)	**a**
2nd Pass	**209**	74.7(0.34)	b	100	5.2(0.11)	b	100	1.23(0.008)	b
Pre-release:									
1st **Pass**	**620**	80.2(0.25)	c	200	6.4(0.10)	c	200	l.2O(O.006)	c
2nd Pass	**654**	84.9(0.22)	d	200	7.6(0.11)	d	200	1.22(0.005)	**d**
Michigan Raceways									
April:									
1st Pass	**273**	73.2(0.28)	e	100	4.9(0.11)	e	100	1.25(0.010)	
2nd Pass	**220**	74.9(0.36)	f	**102**	**5.4(0.11)**	f	102	1.25(0.007)	
3rd Pass	**246**	75.8(0.34)	g	100	5.6(0.13)	f	100	1.26(0.008)	
Pre-release:									
1st Pass	**686**	83.2(0.23)	g	200	7.2(0.11)	gh	200	1.18(0.005)	**h**
2nd Pass	**778**	83.8(0.23)	gh	240	6.9(0.11)	g	240	1.16(0.006)	g
3rd Pass	**631**	84.5(0.26)	h	200	7.5(0.12)	h	200	1.20(0.006)	**h**

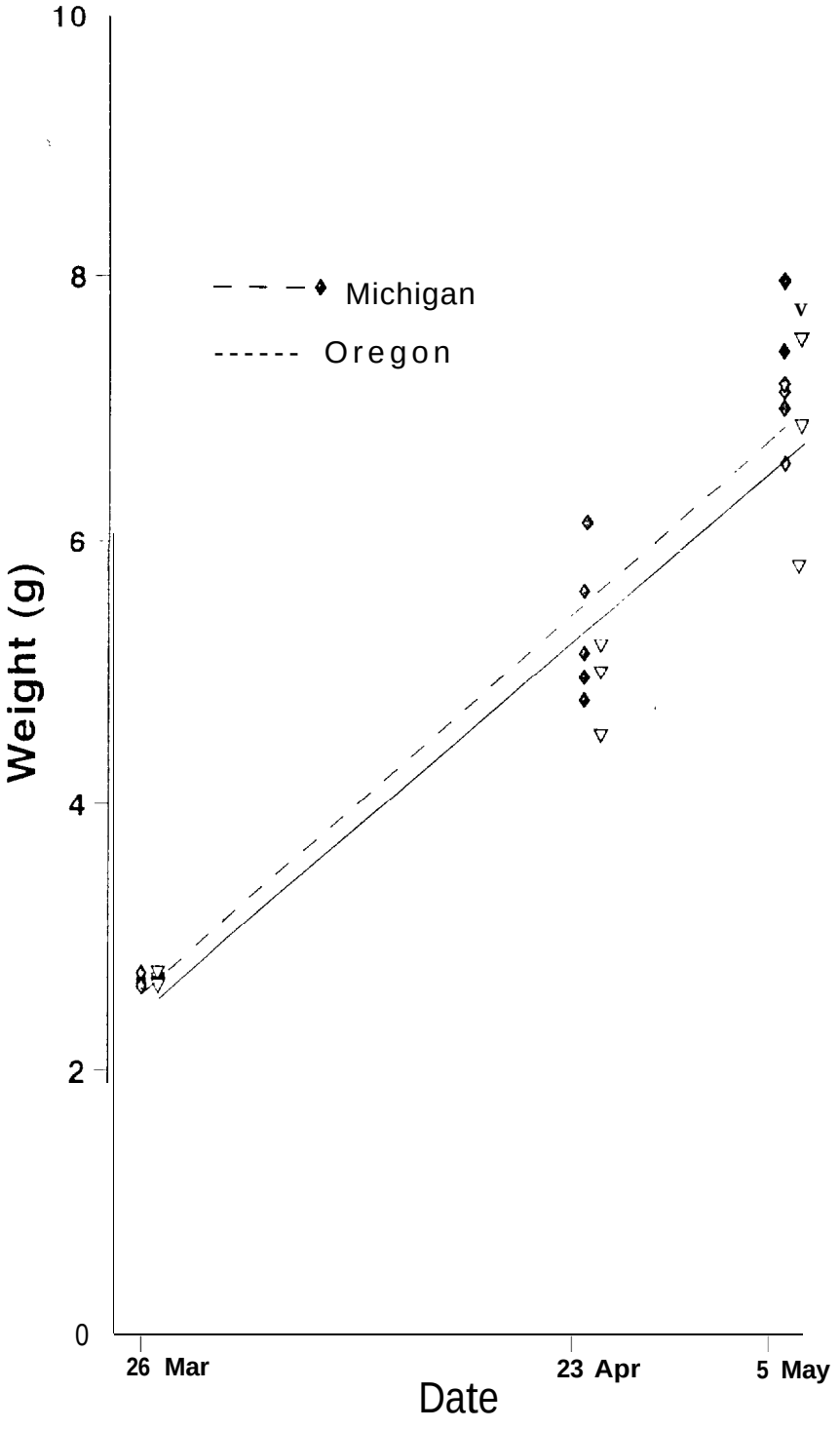

Figure 6. Regression lines of weight measurements by date for fall chinook salmon raised in Oregon and Michigan raceways at Umatilla Hatchery, 1992

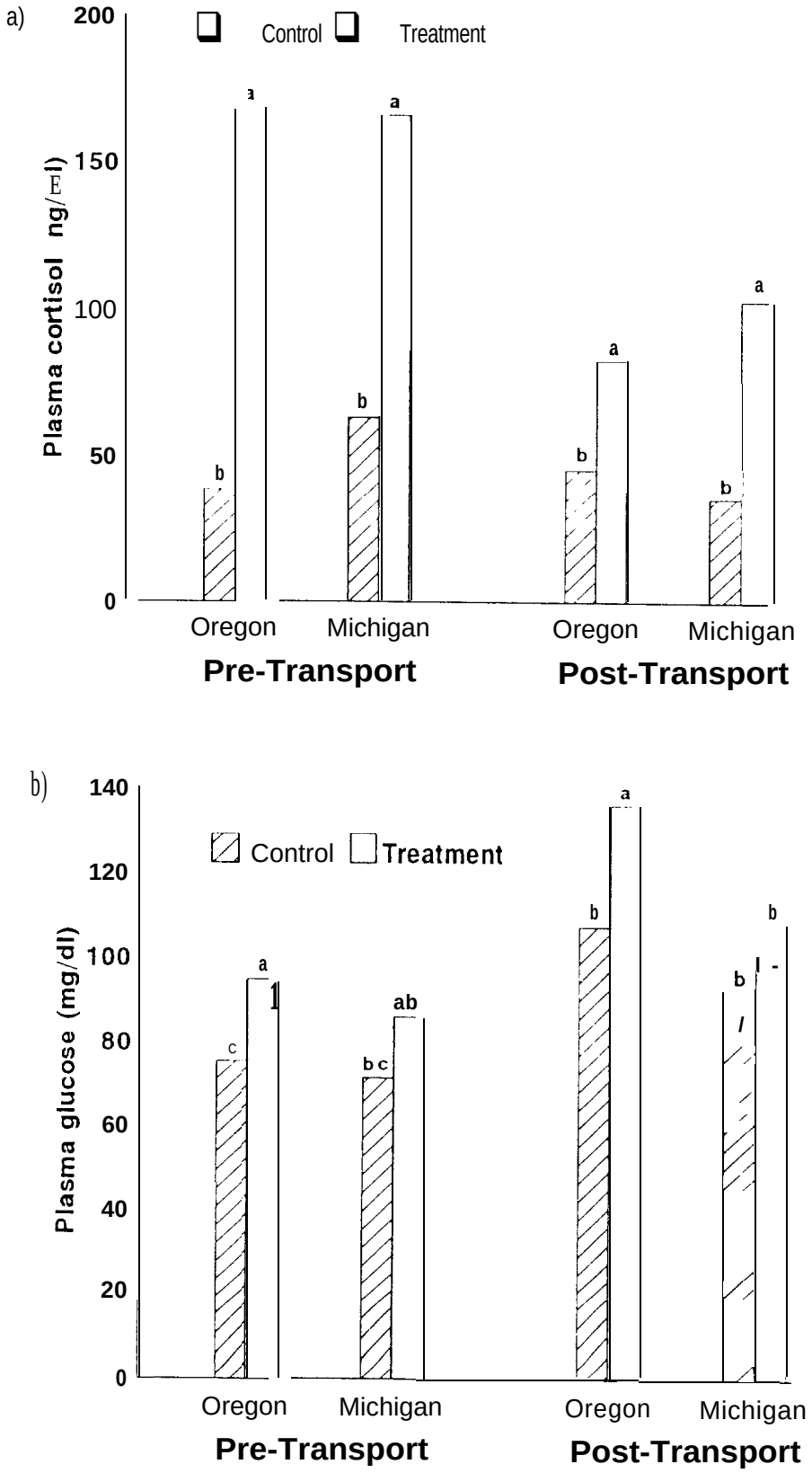

Figure 7. a) Mean plasma cortisol **(ng/ml) and b) plasma glucose (mg/dl) levels of fall chinook salmon from Oregon and Michigan ponds subjected to a standardized stress before and after transportation to the Umatilla River (Within a sample period, means with similar letters are not significantly different (P>O.O5)).**

Table 9. Mean food conversion ratios for fall chinook salmon reared in Oregon and Michigan systems. Data also is presented by raceway position within the Michigan system.

Rearing system, raceway position	N	Food conversion ratio (lb feed/lb fish) Mean(SE)
Michigan :	4[a]	0.97(0.01)
1st Pass	2	0.97(0.00)
2nd Pass	2	0.96(0.02)
3rd Pass	2	1.04(0.05)
Oregon	2[a]	0.99(0.06)

a Combined first and second passes

Smolt Condition: Mean length, weight, and condition factors during pre-release sampling showed significant differences ($P<0.001$) between Oregon and Michigan systems (Table 5). The mean length of fall chinook from Oregon raceways was 1% greater ($P\leq0.0001$) than fish from Michigan raceways, but mean weights were not different ($P>0.45$). The mean condition factor was 0.04 (3%) greater ($P\leq0.0001$) in Michigan raceways. Within the Oregon system, fall chinook salmon from second pass raceways were significantly ($P\leq0.007$) longer (6%), heavier (20%), and had higher (2%) condition factors than fish from first pass Oregon raceways. Within the Michigan system, means of length, weight, and condition factor between first pass, second pass and third pass raceways were significantly different ($P<.0012$) at pre-release. fish from the third pass raceways were slightly longer (l%), heavier (7%), and had higher (1%) condition factors than fish from first and second pass raceways.

The majority of all fall chinook in Michigan and Oregon raceways were intermediate smolts. Although some variability was evident among raceways, none of these differences were significant ($P>0.06$). The mean proportion of fall chinook salmon that was descaled or partially descaled was similar in Michigan or Oregon raceways (Table 10). Considerable variation occurred between raceways, however, no significant difference ($P>0.65$) was found between passes.

Fall chinook salmon that were subjected to a standardized stressor (treatment) had higher plasma cortisol levels than control fish when sampled prior to and after transportation to the release site (Figure 7a). Treatment fish tested after transport appeared to have lower cortisol levels than treatment fish tested at the hatchery prior to transport. In both tests there was a significant treatment effect ($Pt0.0001$) that accounted for a minimum of 66% of the explained variation. There were no differences between Michigan or Oregon system raceways ($P>0.06$).

When we tested glucose levels for salmon in Michigan and Oregon raceways, we found significant treatment ($Pt0.0001$) and system ($P<0.01$) effects both

prior to and after transport. During both sampling episodes, fish that were stressed had higher glucose levels than control fish and Oregon treatment fish had higher levels than Michigan treatment fish (Figure 7b).

The analysis of variance within the Michigan system demonstrated significant differences (P<0.0001) in plasma cortisol between control and treatment fish for both pre- and post-transport samples, although the range of cortisol levels observed in each group were similar (Figure 8). Treatment stress accounted for at least 85% of the variation explained by the model. There was also a significant difference (Pt0.02) in cortisol of fish from different passes within the Michigan system, but the differences were not consistent among pre- and post-transport samples.

An analysis of variance for plasma levels of glucose for fish originating from different passes within the Michigan system demonstrated a significant (Pt0.008) treatment effect for pre- and post-transport samples. Treatment stress accounted for 41-55% of the observed variation (P<0.02), but stressed fish had glucose levels only 9 mg/dl greater than control fish. When glucose was compared for treatment and control groups by pass there was no significant difference (P>0.05) between any of the means in the pre-transport sample (Figure 8). After transport to the release site there was a significant difference among passes (P<0.001) with fish from first pass raceways displaying higher glucose levels than fish from second or third pass raceways.

Table 10. Comparison of the combined mean proportion of descaled, partially descaled, and non-descaled fall chinook reared in Oregon and Michigan systems (SE in parentheses). Michigan system data also is presented by raceway position.

System, raceway position	N	Descaled	Partially descaled	Undamaged
Michigan:	4[a]	0.03 (0.01)	0.36 (0.15)	0.62 (0.16)
First Pass	2	0.04 (0.02)	0.33 (0.23)	0.64 (0.26)
Second Pass	2	0.03 (0.03)	0.38 (0.29)	0.60 (0.30)
Third Pass	2	0.04 (0.01)	0.50 (0.19)	0.47 (0.20)
Oregon	4[a]	0.04 (0.02)	0.61 (0.03)	0.35 (0.03)

a Combined first and second pass raceways.

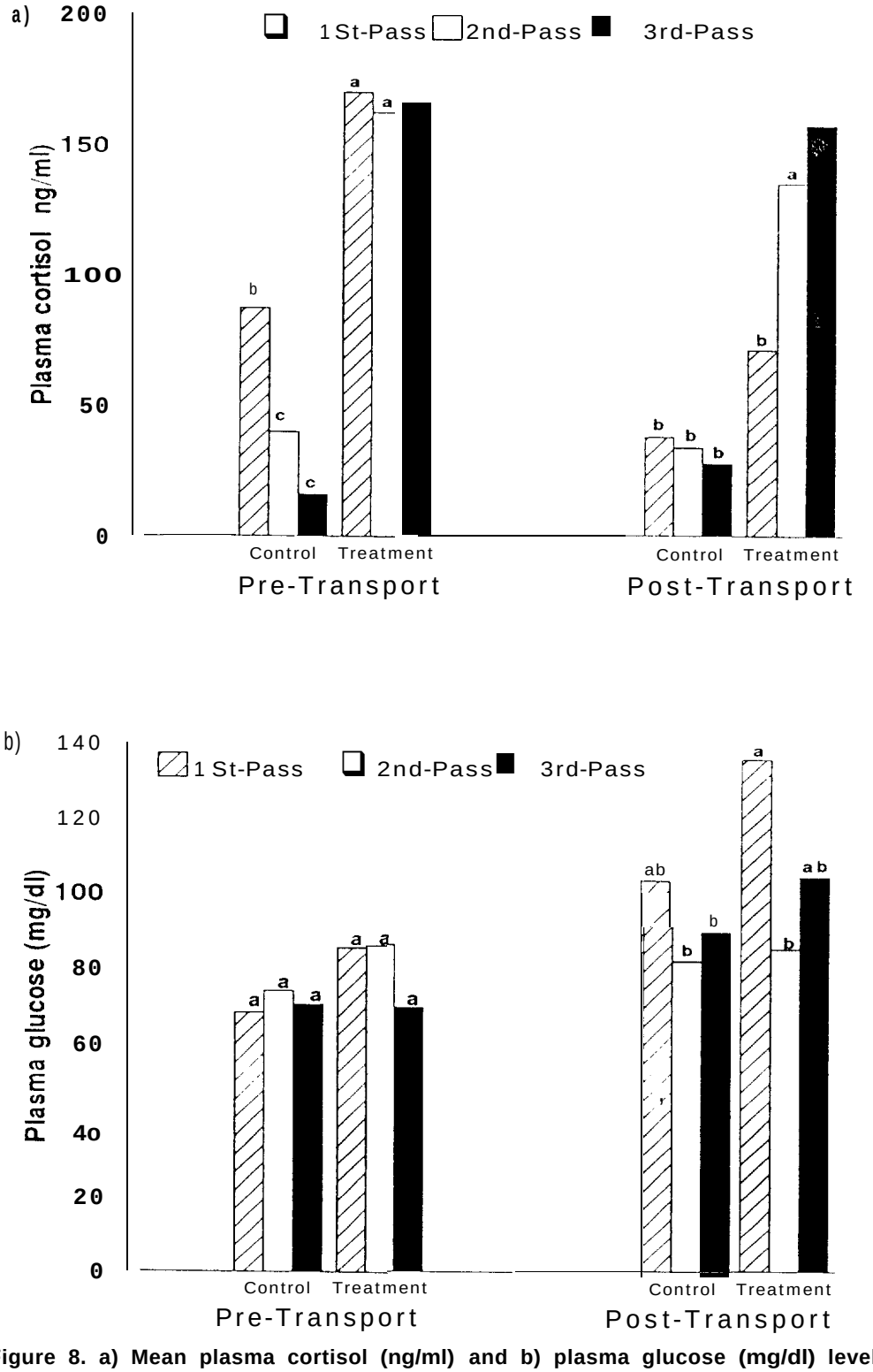

Figure 8. a) Mean plasma cortisol (ng/ml) and b) plasma glucose (mg/dl) levels of fall chinook salmon from lst, 2nd, and 3rd pass Michigan ponds subjected to a standardized stress before and after transportation to the Umatilla River (Within a sample period, means with similar letters are not significantly different (P>0.05).

Smolt Migration Performance: **Approximately** 10,000 **chinook salmon were branded from each Oregon and Michigan raceway (Table** 11). **The numbers of readable brands ranged from 6,572 to 10,442 and varied because of differences in branding technique, brand type, and size. In** general, brands applied **with a l/8" brand were more readable than those applied with a l/16" brand.**

Smolt-to-Adult Survival: The goal of 30,000 coded-wire-tagged fall chinook salmon was achieved or exceeded in seven raceways and was within 4% of the goal in one Michigan and two Oregon raceways (Table 11). **Tag retention ranged from 92.08% to 98.56% and averaged 96.34%.**

Table 11. **Brand and coded-wire-tag information for fall chinook salmon marked at Umatilla Hatchery,** 1992 **(LOC = location of brand, POS = position of brand, RA = right anterior, LA = left anterior, RV = right ventral clip, LV = left ventral clip, CWT = coded-wire tag).**

System, raceway	Number branded	Size	LOC	Brand	POS	Fin clip	Readable brands	CWT code	Number CWT
Michigan:									
2A	**10,665**	**l/16"**	**RA**	E	1	**RV**	**7,445**	**071433**	**29,066**
2B	10,693	**l/16"**	**RA**	E	**2**	**RV**	**9,643**	**071435**	**30,326**
2c	**10,552**	**l/16"**	**RA**		**3**	**RV**	**7,526**	**071437**	**30,508**
3A	**10,756**	**l/16"**	**LA**	E	1	**RV**	6,917	**071434**	**31,224**
3B	10,951	**l/16"**	**LA**	**E**	**2**	**RV**	**7,049**	**071436**	**30,365**
3c	**11,306**	**l/16"**	**LA**	**E**	**3**	**RV**	**7,656**	**071438**	**30,924**
Oregon:									
2A	10,198	l/16"	**RA**	**S**	1	**LV**	9,174	071430	**32,287**
2B	**10,675**	l/16"	RA	E				071432	**29,425**
3A	**10,502**	l/16"	LA	S	41	RV LV	8,558 6,272	071429	**31,842**
3B	**10,601**	l/16"	**LA**	**E**	**4**	**RV**	**8,863**	071431	**28,951**

Spring Chinook Salmon

Rearing Performance: **Spring chinook salmon lengths were significantly (3%; P≤0.0001) greater in the Oregon system than in the Michigan system in** both March and April (Table 12). Although fish from the Oregon system were **significantly heavier in March (l0%, P<0.000l), there was no weight difference** evident in April (P≥0.70). **Michigan system fish had a significantly higher condition factor in April** (P≤0.0001).

Within the Oregon system, lengths and weights were not significantly different (P≥0.13) **in either March or April (Table 13). Condition factor in first pass raceways was higher than second pass raceways in March** (P≤0.007), **but this was reversed in April. There were no differences within the Michigan system in February. Within the Michigan system, spring chinook salmon from third pass raceways were significantly longer (3%; P<0.000l), heavier (8%;**

P≤0.05), and had lower condition factor (3%, P,0.006) than fish from second and third pass raceways during March, but no differences were observed in February or April (Table 13). By April, there was no difference between raceways for mean length or mean weight (P≥0.06). Condition factor significantly declined from first pass to third pass raceways (P≤0.006) in both months.

Despite significant monthly differences in size, growth rates for spring chinook salmon were similar between Michigan and Oregon systems (Figure 7). A test of the slopes of the growth regression lines showed they were both significantly different from zero (Pt0.0001) indicating that growth was occurring; the two slopes, however, were not significantly different (P>0.20). A comparison of spring chinook weights over time in the Michigan system produced slopes of 0.13 for first pass raceways, 0.14 for second pass raceways, and 0.13 for third pass raceways. All slopes were significantly greater than zero (P<0.0001), but no two pairs of slopes were significantly different (P>0.05).

The mean food conversion ratios were not significantly different (P>0.44) between rearing systems (Table 14). Mean food conversion ratios between passes of Michigan raceways also showed no significant differences (P>0.18). Individual raceway food conversion rates ranged from 1.32 to 1.81.

Table 12. Mean monthly and pre-release comparisons of length, weight, and condition factor for spring chinook salmon reared in Oregon and Michigan systems in 1992. Letters indicate results of Sidak multiple comparison test between systems within a sample period. Means without letters are not significantly different (P≥0.05).

Sample, raceway position	Length(mm) N	Length(mm) Mean(SE)	Group	Weight(g) N	Weight(g) Mean(SE)	Group	Condition factor N	Condition factor Mean(SE)	Group
February:									
Oregon	100	67.9(0.41)		50	3.7(0.08)		50	1.18(0.009)	
Michigan	200	67.7(0.29)		100	3.8(0.10)		100	**1.18(0.016)**	
March:									
Oregon	**481**	**80.1(0.21)**	a	203	6.5(0.08)	a	203	**1.22(0.006)**	
Michigan	419	77.9(0.22)	b	210	5.9(0.07)	b	210	**1.22(0.006)**	
April:									
Oregon	525	95.8(0.22)	c	202	**11.4(0.14)**		202	**1.29(0.006)**	
Michigan	**490**	**93.6(0.24)**	d	208	**11.3(0.15)**		208	1.33(0.005)	
Pre-release:									
Oregon	**1250**	**102.8(0.18)**	e	400	14.2(0.13)	e	400	1.27(0.003)	e
Michigan	**1210**	98.6(0.16)	f	**399**	12.9(0.11)	f	**399**	1.31(0.003)	**f**

Table 13. Mean monthly and pre-release comparisons of length, weight, and condition factor for spring chinook salmon reared in first and second pass Oregon raceways and in first, second, and third pass Michigan raceways. Letters indicate results of Sidak multiple comparison test. Means without letters or means with the same letter are not significantly different (P≥0.05).

Sample, raceway position	Lenqtht(m) N	Mean(SE)	Group	Weight(q) N	Mean(SE)	Group	Condition factor N	Mean(SE)	Group
Oregon Raceways									
March:									
1st **Pass**	**255**	**80.3(0.31)**		**103**	**6.5(0.13)**		**103**	1.20(0.009)	a
2nd Pass	**226**	**79.8(0.29)**		100	6.6(0.91)		100	1.24(0.008)	b
April:									
1st **Pass**	**254**	**94.5(0.32)**		102	11.6(0.20)		**102**	**1.31(0.007)**	**c**
2nd Pass	**271**	**96.0(0.30)**		100	**11.1(0.20)**		100	1.26(0.009)	**d**
Pre-release:									
1st **Pass**	**618**	101.9(0.24)	**e**	200	3.9(0.16)	**e**	200	1.29(0.005)	e
2nd Pass	**632**	**103.8(0.25)**	**f**	200	14.6(0.21)	**f**	200	1.25(0.000)	**f**
Michigan Raceways									
February:									
1st Pass	**100**	**68.2(0.38)**		50	4.0(0.11)	g	50	1.20(0.012)	g
2nd Pass	**100**	**67.2(0.41)**		50	3.6(0.11)	h	50	1.15(0.012)	**h**
3rd Pass	**100**	**68.3(0.46)**		50	3.9(0.12)	gh	50	1.19(0.016)	g
March:									
1st **Pass**	**212**	**78.1(0.31)**	i	110	6.0(0.11)	**ij**	110	1.23(0.008)	**i**
2nd Pass	**207**	**77.7(0.31)**	i	100	5.9(0.10)	**j**	100	1.22(0.01)	ij
3rd Pass	**216**	**80.1(0.30)**	j	100	6.3(0.11)	i	100	1.19(0.008)	j
April:									
1st **Pass**	**218**	**94.1(0.36)**		**108**	**11.6(0.21)**		108	1.34(0.008)	**k**
2nd Pass	**272**	**93.1(0.32)**		**100**	**11.0(0.21)**		100	1.31(0.006)	**1**
3rd Pass	280	93.9(0.30)		101	11.O(O.17)		100	1.30(0.007)	**1**
Pre-release:									
1st Pass	**611**	**98.2(0.22)**	**m**	199	12.6(0.17)		199	1.29(0.004)	**n**
2nd Pass	**599**	**99.0(0.23)**	**nm**	**200**	**13.1(0.15)**		200	1.27(0.005)	**m**
3rd Pass	567	99.1(0.23)	n	200	12.7(0.16)		200	1.25(0.005)	o

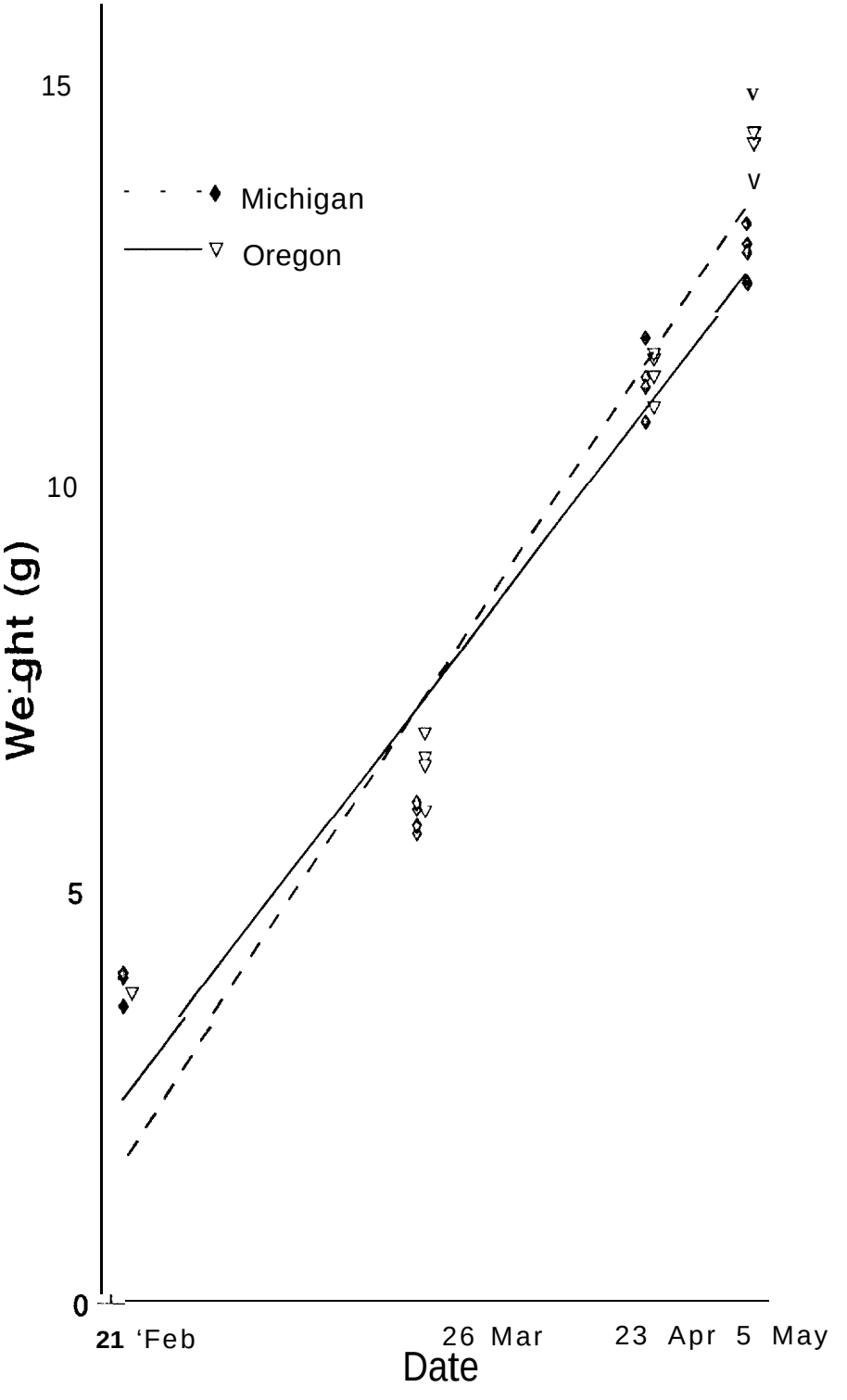

Figure 9. Regression lines of weight measurements by date for spring chinook salmon raised in Oregon and Michigan raceways at Umatilla Hatchery, 1992.

Table 14. Mean food conversion ratios for fall chinook salmon reared in Oregon and Michigan systems. Michigan data also is presented by raceway order.

Rearing system, raceway position	N	Food conversion ratio (lb feed/lb fish) Mean(SE)
Michigan:	4[a]	1.42 (0.06)
1st Pass	2	1.51 (0.06)
2nd Pass	2	1.33 (0.02)
3rd Pass	2	1.60 (0.21)
Oregon	4[a]	1.52 (0.10)

a Combined first and second pass raceways.

Smolt Condition: Mean length, weight, and condition factor at pre-release showed a significant difference ($P<0.0001$) between spring chinook salmon raised in the Oregon and Michigan systems (Table 12). Oregon system fish were 4% longer, 11% heavier, and had a 3% lower condition factor than Michigan fish. Within the Oregon system, pre-release spring chinook salmon from second pass raceways were significantly longer (2%; $P\leq0.02$), heavier (4%; $P\leq0.02$) and had a lower condition factor (3%; $P\leq0.0001$) than fish from first pass raceways (Table 13). Within the Michigan system, spring chinook from second and third pass raceways were 1% longer ($Pt0.05$) and were of similar weight than fish from first pass raceways. The mean condition factor was lowest in the third pass raceway and increased significantly in the second and first pass raceway.

No significant differences ($P>0.86$) were found for pre-release smolt condition either between the Oregon and Michigan systems or within the Michigan system raceways. More than 94% of all fish examined were determined to be intermediate stage smolts. The mean proportion of descaled and partially descaled spring chinook salmon was not significantly different ($P>0.12$) between fish raised in Michigan and Oregon raceways (Table 15). Tests of descaling within Michigan raceways did not show any significant differences ($P>0.62$). The proportion of damaged fish ranged from 0.01 to 0.64 and variability within raceways was high.

Analyses suggested that treatment effects were the most important factors influencing plasma levels of cortisol and glucose in spring chinook salmon (Figures 10 and 11). There were significantly higher ($P<0.0001$) cortisol and glucose levels in stressed fish than control fish for all tests between Oregon and Michigan system raceways and for tests between passes within Michigan system raceways. In addition, fish that were transported and stressed appeared to have increased cortisol levels compared to pre-transport fish that were stressed. Glucose levels of post-transport fish were not elevated above the levels seen for pre-transport fish.

In all cases except one, the effect of stress accounted for the majority of the observed variation. For glucose tests between Oregon and Michigan system raceways, there was a significant system effect (Pt0.001). Stressed and control fish from the Michigan system had elevated glucose levels compared to Oregon system fish prior to transport. No system effect was evident in these groups of fish during the post-transport sample. Tests between first, second, and third pass Michigan raceways were quite consistent and stressed fish usually had higher cortisol and glucose levels than control fish. Although some significant differences (P<0.009) between raceways were found, no pattern emerged.

The levels of ATPase specific activity from spring chinook salmon tested at release in May 1992 were significantly greater (P<0.05) than fish measured at other time periods (Figure 12). Mean activity levels for fish tested at release were 7.7 u-moles P/h/mg protein while the mean activity levels for fish tested on other dates were less than 3.9 u-moles P/h/mg protein. The results of the ANOVA tests suggested that the date was a significant factor (Pt0.0001) affecting our estimates of ATPase specific activity. No other effects were significant (P>0.08).

Table 15. Comparison of the mean proportion of descaled, partially descaled and non-descaled spring chinook reared in Oregon and Michigan systems and in first, second, and third pass Michigan raceways in 1992 (SE in parentheses).

System, raceway position	N	Descaled	Partially descaled	Undamaged
Michigan:	4[a]	0.03 (0.01)	0.01 (0.06)	0.89 (0.07)
First Pass	2	0.03 (0.02)	0.13 (0.12)	0.86 (0.14)
Second Pass	2	0.02 (0.02)	0.07 (0.06)	0.93 (0.08)
Third Pass'	2	0.04 (0.03)	0.35 (0.23)	0.63 (0.26)
Oregon	4[a]	0.01 (0.00)	0.01 (0.00)	0.99 (0.00)

a Combined first and second pass raceways.

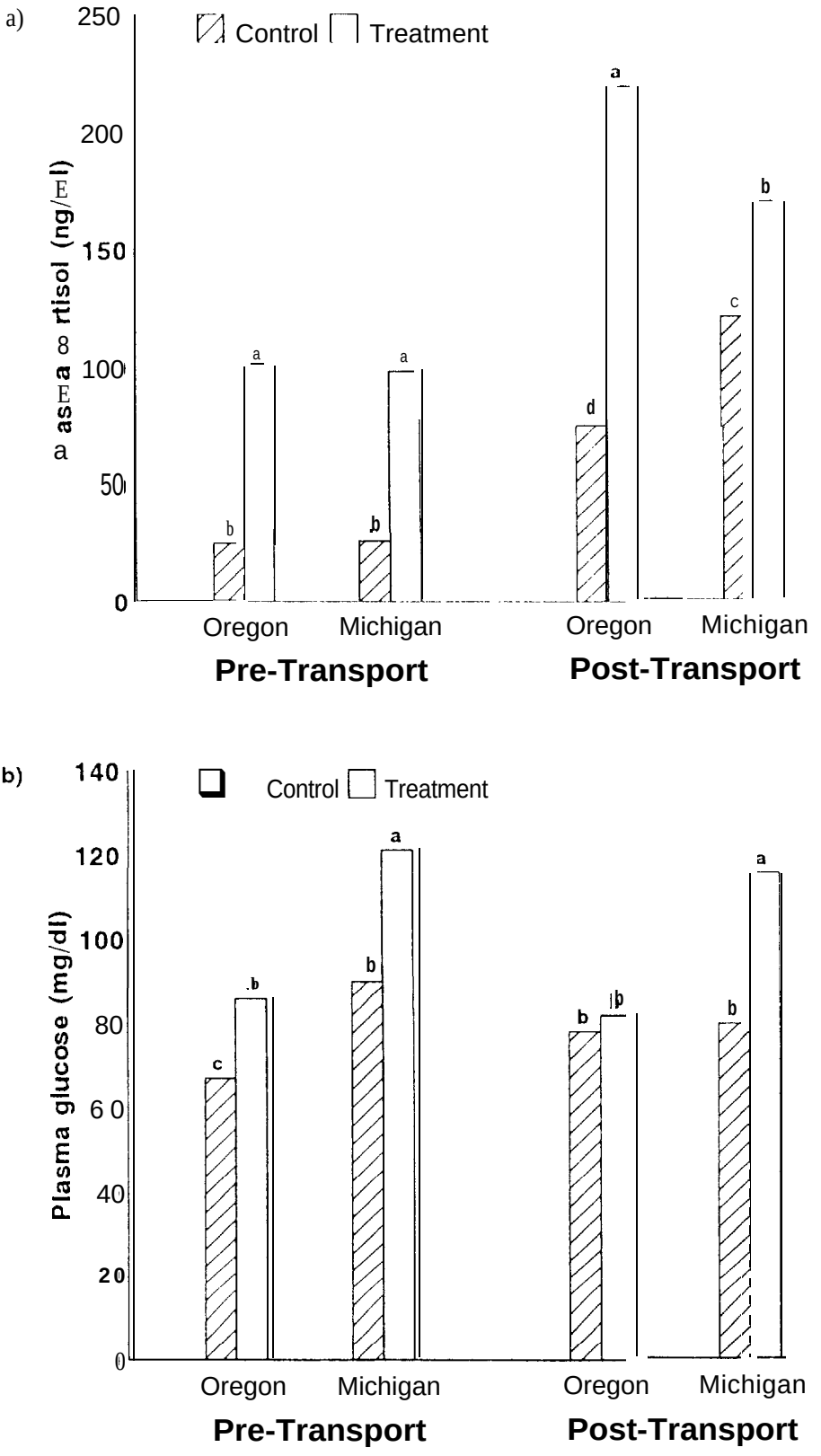

Figure 10. a) Mean plasma cortisol (ng/ml) and b) plasma glucose (mg/dl) levels of spring chinook salmon from Oregon and Michigan ponds subjected to a standardized stress before and after transportation to the Umatilla River (Within a sample period, means with similar letters are not significantly different (P>O.O5)).

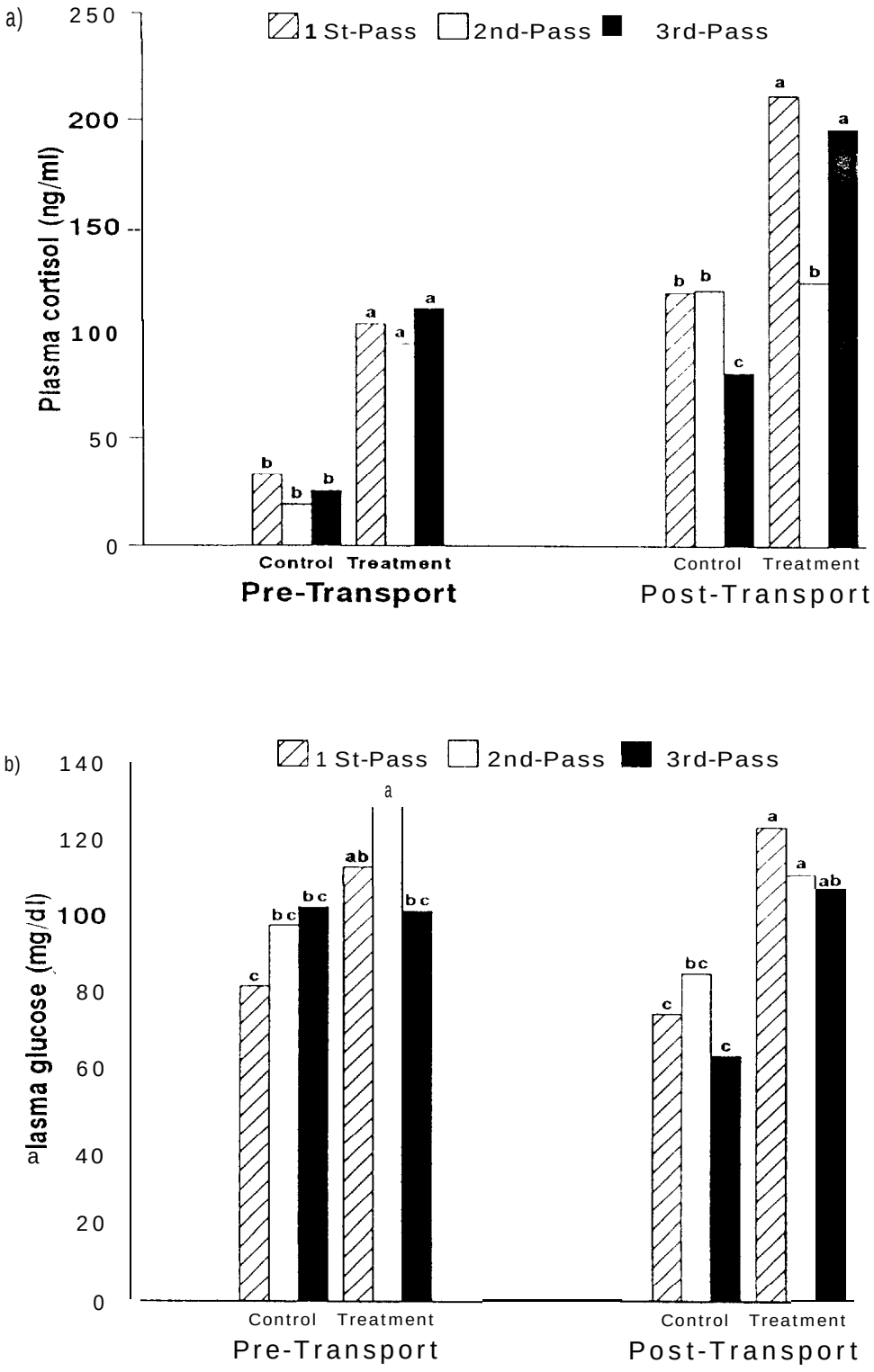

Figure 11. a) Mean plasma cortisol (ng/ml) and b) plasma glucose (mg/dl) levels of spring chinook salmon from lst, 2nd. and 3rd pass Michigan system ponds subjected to a standardized stress before and after transportation to the Umatilla River (Within a sample period, means with similar letters are not significantly different (P>O.O5)).

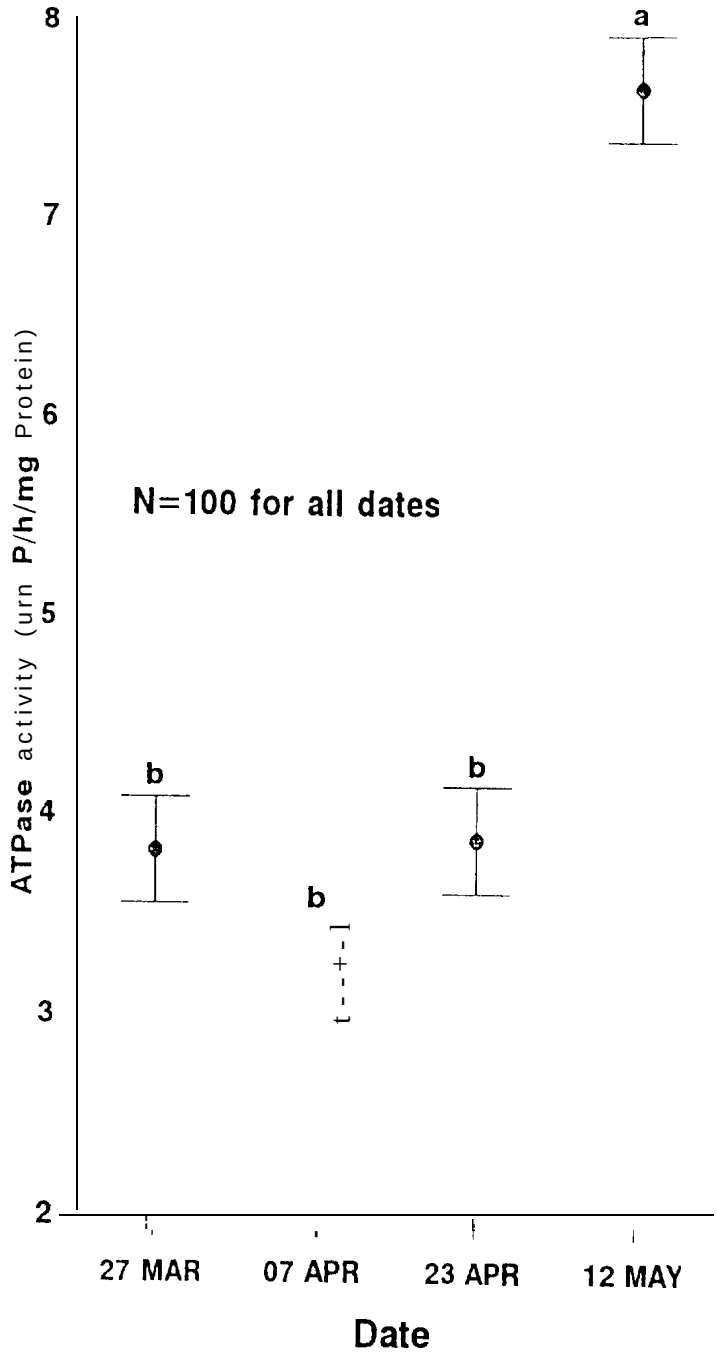

Figure 12. Gill ATPase specific activity (P/h/mg) in spring chinook salmon tested prior to release (April) and at release (May) in 1992 (Bars = 1 SE. Means with similar letters are not significantly different (P>0.05)).

Smolt Migration Performance: Approximately 10,000 chinook salmon were branded from each Oregon and Michigan raceway (Table 16). The numbers of readable brands ranged from 6,572 to 10,442 and varied because of differences in branding technique, brand type and size. In general, brands applied with a l/8" brand were more readable than those applied with a l/16" brand.

Table 16. Brand and coded-wire tag information for spring chinook salmon marked at Umatilla Hatchery, 1992. (POS = position of brand, LOC = location of brand, RA = right anterior, LA = left anterior, RV = right ventral clip, LV = left ventral clip, CWT = coded-wire tag.)

System, raceway	Number branded	Size	LOC	Brand	POS	Fin clip	Readable brands	CWT code	Number CWT
Michigan:									
6A	10,579	1/8"	RA	5	1	RV	9,877	071447	50,047
6B	10,546	l/8"	LA	5	2	RV	10,442	071449	51,518
6C	10,605	l/8"	RA	5	3	RV	9,609	071451	52,128
7A	10,686	l/8"	LA	5	1	RV	9,903	071445	51,703
7B	10,219	l/8"	RA	5	2	RV	9,816	071450	51,271
7c	10,057	l/8"	LA	5	3	RV	9,609	071452	51,659
Oregon:									
4A	10,264	l/16"	RA	B	2	RV	8,393	071443	50,611
4B	10,703	l/16"	LA	B	1	RV	8,384	071464	48,051
5A	10,729	l/16"	LA	B	2	RV	8,195	071446	50,045
5B	10,580	l/16"	RA	B	1	RV	6,572	071445	49,498

Smolt-to-Adult Survival: The goal to place coded-wire tags in 50,000 spring chinook salmon subyearlings in each replicate raceway was reached in eight raceways. We tagged within 4% of our goal in two Oregon raceways (Table 17).

Summer Steelhead

Rearing Performance: We monitored, but did not test, means of length, weight, and condition for summer steelhead since these fish were graded before ponding (Table 17). These differences between raceways carried through into monthly measurements.

The amount of feed needed to raise one pound of summer steelhead at the Umatilla Hatchery increased from the first to the third pass raceway (Table 18). The mean food conversions of all Michigan passes was considerably higher than the 1.10 food conversion for all Oregon raceways at the Irrigon Hatchery. Because replicate data points were not available, tests between Oregon and Michigan raceways could not be completed. Food conversion ratios of each raceway in the Michigan series increased over time (Figure 13).

Table 17. Mean monthly and pre-release comparisons of length, weight, and condition factor for summer steelhead in Michigan first, second, and third pass raceways at Umatilla Hatchery, 1992.

Sample, raceway position	Length(mm) N	Length(mm) Mean(SE)	Weight (g) N	Weight (g) Mean(SE)	Condition factor N	Condition factor Mean(SE)
February:						
1st Pass	**150**	155.8(1.69)	**50**	**49.5(2.36)**	**50**	**1.16(0.01)**
2nd pass	144	167.9(1.43)	49	56.1(2.39)	**49**	**1.12(0.01)**
3rd pass	128	173.3(1.52)	50	62.1(2.42)	50	1.14(0.01)
March:						
1st pass	124	184.6(1.75)	50	88.0(3.29)	50	1.16(0.01)
2nd pass	115	193.6(1.71)	50	88.7(3.40)	50	**1.13(0.01)**
Pre-Release:						
1st **pass**	323	194.3(1.36)	100	91.0(3.21)	100	1.13(0.008)
2nd pass	**328**	**200.0(1.10)**	101	90.2(2.40)	101	1.09(0.008)
3rd pass	**316**	186.9(0.97)	99	76.7(2.10)	99	1.12(0.007)

Table 18. Mean food conversion ratios for summer steelhead reared in Oregon (Irrigon Hatchery) and Michigan (Umatilla Hatchery) systems. Michigan system data also is presented by pass.

Rearing system, raceway position	N	Food conversion ratio (lb feed/lb fish) Mean(SE)
Michigan:	2[a]	1.67 (0.08)
1st **Pass**	1	1.69
2nd Pass	1	2.23
3rd **Pass**	1	3.60
Oregon	30	1.10

a Combined 1st and 2nd pass raceways.

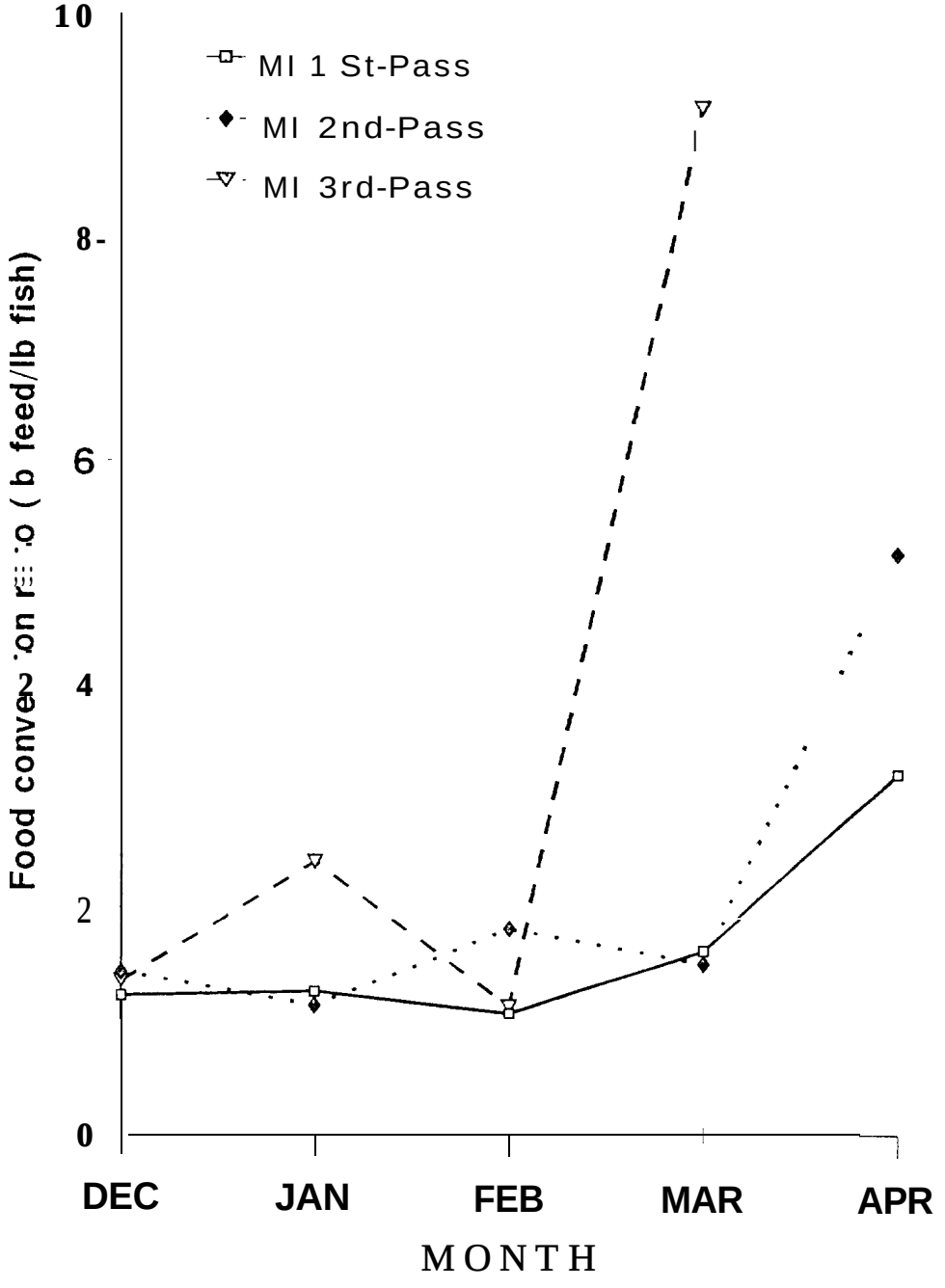

Figure 13. Changes in food conversion ratios over time for summer steelhead reared in Michigan ponds at Umatilla Hatchery, 1992.

Smolt Condition: Pre-release length, weight, and condition factor data of Umatilla River summer steelhead at the Umatilla Hatchery and Wallowa River summer steelhead from the Irrigon Hatchery are presented in Table 17. All fish measured more than 186 mm by the time of release. Because summer steelhead were graded and split into different raceways based on size, we only compared growth between a first pass Michigan raceway and a first pass Oregon raceway from the Irrigon Hatchery. T-tests indicated no significant difference ($P>0.08$) between the raceways for length or weight. However, fish from the Michigan raceway had a significantly higher ($P<0.001$) condition factor than Irrigon Hatchery steelhead.

Summer steelhead from first and second pass raceways were evaluated for descaling (Table 19). The majority of damage was partial descaling and was similar between raceways. Both Umatilla stock and Wallowa stock hatchery steelhead were examined for fin erosion (Table 20). The severity of fin erosion on summer steelhead was variable from raceway to raceway (Table 21). Especially noticeable was the high percentage of steelhead from the third pass raceway, where more than 94% of fish examined had severely damaged dorsal and pectoral fins.

Table 19. Comparison of the proportion of descaled, partially descaled and undamaged (not descaled) summer steelhead reared in first and second pass Michigan raceways at Umatilla Hatchery, 1992. Data for the third pass raceway were not available.

System, raceway position	N	Descaled	Partially descaled	Undamaged
Michigan:				
1st pass	200	0.01	0.43	0.56
2nd Pass	200	0.05	0.39	0.61

Table 20. Fin erosion comparison of summer steelhead reared in Michigan raceways at Umatilla Hatchery (Umatilla stock) and summer steelhead reared in an Oregon raceway at Irrigon Hatchery (Wallowa stock), 1992.

Fin type	Percent of fish with eroded fins			
	Michigan 1st pass	Michigan 2nd pass	Michigan 3rd pass	Oregon 1st pass
Dorsal	98.5	100.0	99.5	100.0
Caudal	96.0	100.0	99.5	0.0
Anal	0.0	0.0	8.0	0.0
Ventral	3.0	0.0	6.5	4.5
Pectoral	96.0	100.0	10.0	55.5

Table 21. Severity of fin erosion among summer steelhead (Umatilla River stock) reared in Michigan raceways at Umatilla Hatchery, 1992.

Fin	Percent severity of fin erosiona								
	Light			Moderate			Severe		
	1st pass	2nd pass	3rd pass	1st pass	2nd pass	3rd pass	1st pass	2nd pass	3rd pass
Dorsal	17.8	68.8	15.4	78.2	27.1	4.2	4.0	7.7	94.8
Caudal	1.8	15.6	0.0	98.2	84.4	0.0	0.0	0.0	0.0
Pectoral	42.9	62.9	2.1	53.6	18.0	0.0	3.5	19.1	97.9

a light erosion = more than 90% of fin remaining, little or no damage.
Moderate erosion = fin approximately 50% eroded.-
Severe erosion = less than 25% of fin remaining, almost no fin rays visible.

Spring Chinook Yearling and Subyearling Production Evaluation

The goal of coded-wire tagging 20,000 spring chinook yearlings and 30,000 subyearlings per raceway was achieved for four raceways of yearlings and 10 raceways of subyearlings at Umatilla Hatchery (Table 22). Tag retention for Umatilla yearlings will be included in the 1993 annual. Tag retention data for Umatilla subyearlings was presented previously. The goal of coded-wire tagging 20,000 spring chinook yearlings was achieved for two raceways at Bonneville Hatchery. Tag retention ranged from 92.5% to 94.9% for two raceways of yearlings reared at Bonneville and averaged 93.7 %.

Table 22. Numbers of recognizably coded-wire-tagged and adipose clipped spring chinook yearlings at Umatilla and Bonneville hatcheries.

Hatchery	Raceway	Tag code	Number
Umatilla	05A	075742	21,107[a]
	05B	075739	22,171[a]
	04A	075741	21,336[a]
	04B	075740	21,088[a]
Bonneville	Bl	071455	20,035
	B2	071456	20,107

[a]These numbers will change after tag retention check on 11/03/92.

Effects of Harking on Subyearling Fall Chinook Salmon

A summary of body tagging and fin marking for the marking evaluation is presented in Table 23. Tag retention for body-tagged groups ranged from 93.5% to 100.0% and averaged 96.3%. Tag retention for groups marked AD+CWT were 97.5% and 99.3%. Future adult fall chinook returns will be analyzed to determine the influence of different tag and marking techniques on survival to adulthood.

Table 23. Numbers of fall chinook salmon marked at Irrigon and Umatilla Hatcheries to study the effects of tagging.

Mark	Irrigon Hatchery 1990	Umatilla Hatchery 1991
Left ventral		69,816
Body tag & left ventral	-	65,749 67,144
Body tag	147,586	70,435 65,184
Adipose & coded-wire tag	104,258	
Adipose & coded-wire tag & right ventral	103,980	31,982 32,287
Adipose & coded-wire tag & body tag	145,048	-

Creel Survey

The primary goals of the Umatilla creel survey are 1) to identify recreational fishing areas that are used for fall chinook, spring chinook, and summer steelhead; 2) to develop and implement statistical methods to estimate total effort, total catch, total harvest, and number harvested by tag code for fall chinook, spring chinook, and summer steelhead recreational fisheries; and 3) to coordinate with the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) in their development of a monitoring program for tribal fisheries.

The creel survey was divided into three separate surveys because of the split fishing seasons. An early fishing season for coho salmon and chinook salmon jacks (16-24 in) exists in the lower Umatilla River to the boundary with the Columbia River and runs from 1 October to 30 November. A later steelhead season includes the entire river from the CTUIR reservation lower boundary in Pendleton to the mouth of the Umatilla and runs from 1 December to 31 March. Since most of the river is surveyed, we divided the river into a lower and an upper reach. There may be a spring chinook season which will start after 31 March, but it is dependent on total returns. We will survey the spring chinook fishery if it occurs.

The survey methods used for all seasons will be similar, but will be adjusted as we learn more about the fisheries in 1992. We plan to survey during all weekends and holidays. The remaining days within the month will be systematically assigned to assure accurate coverage of all days of the week throughout each month.

We will use a roving creel design to make instantaneous counts of fishing pressure and to contact anglers. Sampling will be stratified into monthly estimates by day type to reduce variation. We have identified day types as "weekend/holiday" and "weekday". Day type strata will be combined to estimate the fishing pressure for each month. In addition, monthly estimates will be combined to make an estimate for the entire fishing season.

Anglers will be interviewed to obtain data on hometown, hours fished, number and types of fish caught, and lengths of fish. In addition, the creel clerk will obtain scales from all adult fish (>24 in) and snouts from all fish that possess CWTs. Examples of the count and angler interview forms to be used are presented in Appendix A.

For the fall chinook and coho salmon survey, we will make instantaneous counts of anglers three times per day. The time of the first count will be randomly selected from a choice of four starting times in the two hours after legal fishing time. Subsequent counts will follow at 3.5-4.5 hour intervals. Each count period should take approximately 30-45 minutes to complete. Anglers will be interviewed between count periods.

The summer steelhead creel survey will be finalized by 10 November 1992. We will probably divide the river into two or three reaches to adequately cover the entire area open to angling. Each sample day will be divided into two non-overlapping 5-hour shifts (early and late). Shifts will be selected so that each river reach is sampled a minimum of two early and two late shifts per month per day type. During each shift we will make two pressure counts, The count start times will be randomly selected, but will be at least two hours apart to allow for travel and interview time. Counts can be started at either end of the reach and may take up to one hour. Therefore, we also will randomize whether the count starts at the upstream or downstream end of the reach. Anglers will be interviewed between count periods, although some may be interviewed during the counts to maximize complete angler interviews. We will use the same data forms used in the fall chinook and coho salmon surveys.

Fishing pressure for each sample day (Hi) will be estimated by developing a pressure curve from pressure counts and calculating the area under the curve (AUC) as follows:

$$Hi = 1/2 \sum_{k-1}^{r} (T_k - T_{k-1})(C_k + C_{k-1})$$

where
r = number of pressure counts per day,
Ck = angler count at time k, and
T_k = time at the k^{th} count.

We assume the fishing day starts one-half hour before sunrise and ends one-half hour after sunset.

The catch per hour (Ri) will be estimated as:

$$Ri = \sum_{k=1}^{m_i} fij \; / \sum_{j=1}^{mi} hij$$

where
m_i = number of anglers interviewed o ^{h} the i^{th} day,
f_{ij} = number of fish caught by the ^{h} angler on the j^{th} day, and
h_{ij} = number of hours/fish by the j^{ih} angler on the i^{th} day.

The total daily catch (TC_i) will be estimated by:

$$TC_i = (R_i)(H_i)$$

The total catch for a stratum within a month (TC) will be determined by:

$$TC = (N/n) \sum_{i=1}^{n} TC_i$$

where
N = number of days in the stratum for the month, and
n = number of days sampled in the stratum.

The variance of catch V(TC) (Cochran 1977) for each stratum within each month will be calculated as:

$$V(TC) = N^2(1-(n/N))(S_i^2/n) \; t \; (N/n) \backslash \; (1-(\sum_{j=1}^{m_i} h_{ij}) / H_i) (H_i^2) (S_{2i}^2/m$$

where

$$S_i 2 = \sum_{i=1}^{n} (TC_i - TC)/(n-1),$$

$$S_{2i}2 = \sum_{j=1}^{m_i} (f_{ij}/h_{ij} - R_i)^2/m_i-1, \text{ and}$$

$$TC = \sum_{i=1}^{n} TC_i/n$$

Total monthly catch and variance will be determined by summing stratum totals and variances. Angler days will be determined from total hours and the average length of an angler trip. Catch rate (CR), expressed in fish per hour, will be calculated for each stratum within each month as follows:

$$CR = \sum_{i=1}^{n} H_i R_i / \sum_{i=1}^{n} Hi$$

Catch rates for combined monthly strata (CR_m) and total season (CR,) will be weighted by the proportion of total hours flshed in each stratum.

The total number of fish harvested (TH) for each stratum within a month will be determined by:

$$TH = \sum_{i=1}^{n} Pi \; TC_i$$

where
P_i = proportion of catch on day i that was harvested.

The variance of the number of fish harvested within a stratum will be estimated as the variance of the product of two random variables.

Planning and Coordination

The research monitoring and evaluation team has participated in planning and coordination activities for the Umatilla Basin. We have assisted the Confederated Tribes of the Umatilla Indian Reservation in preparing the natural production proposal. We have participated extensively in hatchery production planning. We have recommended modifications for Umatilla Hatchery production that have been implemented by the managers, such as the decrease in steelhead production to decrease steelhead raceway densities and the implementation of a fall release program for spring chinook.

DISCUSSION

Fish Cultural Practices

Overall hatchery production was well below the production plan goals for the Umatilla Hatchery this year because of water shortages. Consequently, we did not achieve our production goals for spring or fall chinook salmon. Approximately 2.7 million fall chinook salmon were released. This number of smolts released was 3.2 million below our 1991 brood goal of 5.9 million. Approximately 955,000 subyearling spring chinook were released as compared to our goal of 1.08 million. We were slightly below our summer steelhead production goal of 210,000 smolts; approximately 205,000 summer steelhead were released into the Umatilla River.

It is unlikely that additional water can be provided at the facility in the near term to achieve full capacity. In fact, additional water shortages have led to further reductions of 230,000 subyearling spring chinook. Therefore, the total subyearling chinook production for the 1992 brood will be 720,000 smolts.

To help compensate for the decreased production at Umatilla Hatchery, we recommended that a spring chinook fall release program be initiated. For the 1991 brood spring chinook, this program entailed keeping approximately 106,000 surplus spring chinook eggs and rearing them for release in November of 1992. Starting with the 1992 brood, the program will be expanded to incorporate a full Michigan versus Oregon rearing system evaluation. This will result in production of 492,000 spring chinook for fall release. With the addition of 492,000 fall release fish, hatchery production will be increased to 1.5 million spring chinook smolts.

Overall egg-to-smolt survival at Umatilla Hatchery was better than expected. The fry-to-smolt survival rate of fall chinook progeny of adults that returned to the Umatilla River and reared at Irrigon Hatchery was the best of all groups at 84.7%. This value compares with the predicted survival rate of 64% and the observed 55% for Upriver Bright fall chinook that were reared from eggs incubated at Bonneville Hatchery. The Upriver Bright-Bonneville Hatchery fall chinook were the only stock not to exceed predicted survival rates. This may in part be due to cold water disease that occurred during the extensive marking period one month prior to release. Carson stock spring chinook egg-to-smolt survival rate exceeded the predicted rate by 5.5%.

Umatilla stock summer steelhead exceeded the predicted egg-to-smolt survival rate by 6.7%.

Although hatchery survival was high, hatchery growth was generally poorer than anticipated. Fall chinook were liberated at 63 and 65 fish/lb for Michigan and Oregon systems respectively. These fish were slightly smaller than the target size of 60 fish/lb. It is important to point out that because tagging and marking of fall chinook took much longer than anticipated, these fish were held at the hatchery for an extra two weeks. These fish would have been even smaller if they had been liberated on schedule. The month of time (April) required for marking and tagging fall chinook, along with the outbreak of cold water disease, are possible reasons for the fish not reaching programmed size within the expected timeframe. It is common for fish stressed by handling or disease to reduce feeding and subsequently experience diminished growth. However, diminished growth during April is not evident from monthly length and weight data. In an attempt to circumvent this problem next year, we are working with hatchery personnel to devise an alternate marking and tagging scheme. In addition, the release date for 1992 brood fall chinook has been shifted later by two weeks allowing an additional two weeks of growth.

Spring chinook smolts liberated from Umatilla Hatchery were well under the size-at-release target of 15 fish/lb, averaging 35 and 32 fish/lb for Michigan and Oregon systems respectively. There are two major factors that contributed to the small size-at-release. First, it appears that the initial release size goal was unrealistic and will not be achievable given the conditions at Umatilla Hatchery. After this first year of production we estimate that the maximum size-at-release we can achieve under the best scenario at Umatilla hatchery will be 20-25 fish/lb for spring chinook subyearlings. In addition, we were unable to incubate and rear the 1991 brood as originally planned because Umatilla Hatchery was not completed and was not ready to receive eggs in August when the eggs were taken at Carson National Fish Hatchery. We anticipate the decrease in size-at-release of spring chinook will result in decreased smolt-to-adult survival and adult returns as compared with original estimates used in the Umatilla Hatchery Master Plan (CTUIR and ODFW 1990).

Size-at-release for summer steelhead was variable among raceways. The largest fish were reared in the third pass of the Michigan raceway and did not meet the size-at-release goal of 5 fish/lb at release into the Umatilla River. These fish averaged 6.1 fish/lb when transferred to the acclimation facilities and, although they did experience some growth during acclimation, they were only 5.8 fish/lb at release. Steelhead from the first and second pass raceways were released at the target size of 5.0 fish/lb. The liberation of fish from the second pass was delayed two weeks to give the fish additional opportunity for growth. These fish would have been slightly under the size-at-release goal had they been released on schedule.

The most probable factor affecting size-at-release in summer steelhead is food conversion. Food conversion in all three passes of the steelhead series was less efficient than fish reared in standard systems. In addition, food conversion efficiency decreased from pass one to pass two and then again to pass three. This decrease in food conversion efficiency corresponds with increasing fish density from pass one to pass three. In addition, more

detailed examination of food conversion ratios by month demonstrates a considerable rise over time, which again corresponds to increasing densities of fish in the passes over time. A positive relationship between raceway density and food conversion has also been demonstrated in rainbow trout reared in oxygen supplemented systems (Kindschi et al. 1991a).

Water Quality Monitoring

The water quality at the Umatilla Hatchery was similar for salmon raised in the Oregon raceways and for salmon and steelhead raised in Michigan raceways. Although oxygen levels dropped below 6.5 ppm on occasion, it is unlikely that the health of the fish was compromised. Saturation was never below the 60% level at which growth (Westers 1989; Klontz et al. 1983) and the ability of fish to tolerate ammonia is affected (Thurston et al. 1981). In addition to the water quality data we collected, personnel at the Umatilla Hatchery also monitored oxygen and generally found levels to be above 6.5 ppm. Maximum levels of dissolved oxygen in oxygen supplemented raceways were below levels that cause damage because of chronic exposure (Colt et al. 1991). The differences in total gas pressure that were observed between systems and within a system were marginal and should not result in other water chemistry differences between raceways. Alkalinity was high, and the buffering capacity kept pH levels well within the recommended ranges (6.0-9.0; Colt 1991). However, given the substantial buffering ability of the water, it is somewhat surprising that we observed decreases in pH from the head to the tail of several raceways in the range of 0.3-0.5 pH units. Because we did not monitor water quality at the Irrigon hatchery, we cannot be sure all water conditions were equal for summer steelhead.

Rearing Performance and Survival Studies

Monthly monitoring of rearing parameters demonstrated differences in size of fall and spring chinook both between and within Michigan and Oregon systems. For fall chinook the differences between the systems were small, variable, and probably not biologically meaningful. The largest difference, a 2% increase in length that Michigan system fall chinook demonstrated during rearing, was no longer evident one month later at pre-release sampling. Fall chinook size differences within the Michigan and Oregon systems were consistent and suggest that rearing salmon lower in the system at slightly lower densities produces larger salmon with higher condition factors.

Comparison of spring chinook sizes between the Michigan and Oregon systems and within each system showed considerable variability during rearing. Several differences in size that were evident in the first monthly sample were no longer present in the second sample, suggesting these differences are not biologically significant. Two general trends were evident for spring chinook. Unlike fall chinook salmon, spring chinook reared in the Oregon system were larger than salmon reared in the Michigan system. On the other hand, spring chinook were similar to fall chinook in that second and third passes appeared to produce bigger fish within each system.

Growth rates and food conversion were similar between fall chinook reared in Michigan and Oregon raceways even though the densities of fish in Michigan

raceways were approximately four times greater than the fish densities in the Oregon raceways. These similarities in rearing performance were also evident for spring chinook that were reared in Michigan raceways at densities three times greater than densities of spring chinook in Oregon raceways. These data are consistent with previous studies on salmon that have found no effect of density on growth (Patino 1986) and food conversion (Poston 1983).

Although the direct comparison of rearing summer steelhead in Michigan and Oregon systems cannot be made, we were able to indirectly compare steelhead reared in Michigan raceways at Umatilla Hatchery with steelhead reared in Oregon raceways at the nearby Irrigon Hatchery. Food conversion ratios differed considerably between the groups. The higher estimates of food conversion for steelhead at Umatilla may be related to the higher densities steelhead experience in Michigan raceways. Rainbow trout reared at different densities in an oxygen supplemented system exhibited increased food conversion in the raceways with increased density (Kindschi et al. 1991a). The densities of the Michigan reared steelhead at Umatilla were approximately five times greater than densities of steelhead reared in standard Oregon systems and may have been high enough to have affected food conversion. The presence of baffles in the Michigan raceways may also have affected steelhead food conversion. Rainbow trout reared in baffled raceways exhibited less efficient food conversion than trout reared in identical raceways without baffles (Kindschi et al. 1991c). Alternatively, the differences in food conversion may simply reflect differences between stocks or hatchery practices.

The smolt condition evaluation included information on length, weight, and condition factor at release, a visual index of smoltification, descaling index, fin erosion, physiological stress indices, and gill Na+K+ATPase. However, not all parameters were evaluated for all races reared at the hatchery. Significant differences between fish reared in the Michigan and Oregon systems were evident for both fall and spring chinook salmon. Fall chinook reared in the Michigan system were approximately 1% longer, but were of similar weight to fall chinook reared in the Michigan system. The pattern for spring chinook salmon was reversed with fish from the Oregon system averaging 4% longer and 11% heavier. Within the Michigan system although both spring and fall chinook appeared to be larger in the third pass raceways, this difference was slight. However, within the Oregon system, the second pass fish were both longer and heavier than fish from the first pass raceways and therefore may have some survival advantage. A rough comparison of steelhead reared in the Michigan system with other steelhead reared in standard Oregon raceways suggested that these fish were smaller at release.

The differences in size of steelhead and salmon at release may be a function of rearing density (Kindschi et al. 1991b, Poston 1983, Martin and Wertheimer 1989). Overall, the groups of fish that were both longer and heavier in this study were reared in Oregon raceways at lower densities than the Michigan raceways. Even the larger fish from the second pass Oregon raceways were reared at reduced densities compared to the first pass Oregon raceways. It appears reasonable to suggest that the differences in rearing density between raceways and systems is influencing the size of fish at release.

It is uncertain whether the size difference seen in the fall and spring chinook salmon in this study will affect post-release growth or survival.

Elrod et al. (1989) released lake trout from low density rearing raceways that were 6% longer and 22% heavier than fish released from high density raceways. When recovered two years later, there was no significant difference in size between the two groups, but trout from the low density raceways had 20% greater post-stocking survival than the smaller trout from the high density raceways. Based on the findings of Elrod et al. (1989), we might anticipate that Umatilla spring chinook reared in the Oregon system may have increased post-stocking survival over those reared in the Michigan system Furthermore, we might expect that both spring chinook and fall chinook reared in second pass Oregon raceways will survive better than the respective groups reared in first pass Oregon raceways.

The visual index of smoltification was similar among fall chinook, spring chinook, and summer steelhead. The majority of all smolts released were in transition from the parr to smolt stage and had at least some degree of descaling. Fin erosion was not evaluated for salmon. Fin erosion for steelhead was considerable and was more severe than previously recorded at northeast Oregon hatcheries. Not only was there increased incidence of severe erosion of commonly eroded fins, such as the dorsal fin, but there was also a high percentage of erosion to uncommonly eroded fins, such as the caudal fin. The cause of the fin erosion is unclear. It is possible that the densities of steelhead in the Michigan raceways increased contact among individuals which resulted in more prevalent fin erosion. However, Kindschi et al. (1991b) demonstrated that increasing densities of rainbow trout does not result in increased dorsal fin erosion. A second alternative is that the baffles in the Michigan raceways can result in increased fin erosion. This possibility is also contrary to the available literature which suggests (Kindschi et al. 1991c) that rainbow trout reared in baffled raceways actually have less dorsal fin erosion than trout reared in standard raceways.

Gill Na+K+ATPase was used as a physiological index of smoltification for spring chinook salmon. The levels of gill ATPase were always within the reported ranges for spring chinook salmon (Congelton et al. 1984), yet the increased levels at release were generally lower than reported values for salmon smolts at release (Hoar 1988). These low levels most likely reflect that Umatilla spring chinook were released in the initial stages of smoltification. The size of the fish at release was below the desired size-at-release goal for Umatilla Hatchery spring chinook and was generally smaller than the size-at-release of most hatchery spring chinook, perhaps explaining why these salmon were just beginning smoltification.

Stress tests were conducted on spring and fall chinook salmon to evaluate the effects of the different rearing systems on the ability of the salmon to respond to a stressor. Values of both cortisol and glucose were consistent between fall and spring chinook salmon and with data from several different hatchery stocks (Congelton et al. 1985). Although crowding stress is known to increase plasma levels of cortisol and glucose (Schreck et al. 1985), the increased densities in Michigan raceways during this study did not result in increased plasma hormone when compared with salmon reared in the Oregon system. Furthermore, the increase in hormone levels of both pre- and post-transport treatment groups indicates that salmon reared in the Michigan system were equally capable of mounting a physiological stress response as salmon reared in the Oregon system. Although there were some significant differences in cortisol responses among passes within the Michigan system, no consistent

pattern emerged to indicate that fish in any one pass have a diminished or **enhanced capacity to respond to a stressor.**

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APPENDIX A
Examples of angler pressure and angler interview forms for creel surveys

UMATILLA RIVER CREEL SURVEY
ANGLER INTERVIEW FORM

SURVEYOR _____ SECTION _____ PAGE ___OF___

CALENDAR DATE /_____/ DAY TYPE _____

ANG NUM	ANGLER ORIGIN	AN DE	TRIP	HOUR FISHE	GEAR	SPP	MAR REL	UNM REL	SEX	FORK LNTH	FIN MARK	SNOU LABEL	SCALE LABEL

[9]

UMATILIA RIVER CREEL SURVEY
ANGLER PRESSURE COUNTS

DATE ________

SUNRISE ________ SUNSET ________

TIME OF FIRST PRESSURE COUNT ________

DIRECTION OF FIRST COUNT ________

SURVEYOR ________

TIME PERIOD	RIVER SECTION	ANGLER TALLY	VEHICLE TALLY	TOTAL ANGLERS	TOTAL VEHICLE

TIME PERIOD	RIVER SECTION	ANGLER TALLY	VEHICLE TALLY	TOTAL ANGLERS	TOTAL VEHICLE

TIME PERIOD	RIVER SECTION	ANGLER TALLY	VEHICLE TALLY	TOTAL ANGLERS	TOTAL VEHICLE

TIME PERIOD	RIVER SECTION	ANGLER TALLY	VEHICLE TALLY	TOTAL ANGLERS	TOTAL VEHICLE

FISH HEALTH MONITORING AND EVALUATION

INTRODUCTION

Integration of a systematic fish health monitoring regimen with other hatchery production monitoring and evaluations is a unique aspect of the Umatilla Hatchery program. Because of the disparate rearing strategies between Oregon and Michigan raceways, the occurrence of infectious diseases and overall fish health also might be significantly different between various production lots. Any differences in the occurrence of infectious diseases may well affect losses during rearing in the hatchery, as well as survival to the adult lifestage. Integrating fish health and hatchery evaluations affords an opportunity to quantitatively assess disease related effects on survival and to employ prospective epistemology rather than a retrospective approach (Klontz 1993) to evaluate the occurrence of diseases.

The fish health monitoring program was designed to detect pathogens and conditions that might be anticipated considering the fish species and stocks, and the rearing strategies used in Umatilla Hatchery production. Both the Bonneville and Carson chinook used as brood stock for the Umatilla program are known to have a high carrier rate of infectious hematopoietic necrosis virus (JHNV) at spawning. Although studies by the Oregon Department of Fish and Wildlife have failed to confirm vertical transmission of IHNV in salmonid production in Oregon (Engelking et al. 1991; LaPatra et al. 1991), monitoring progeny for this potentially devastating virus is prudent. Erythrocytic inclusion body syndrome (EIBS) is a blood-borne viral infection that can cause anemia and result in certain secondary infections of chinook and coho salmon (Holt and Piacentini 1989). This virus is thought to be transmitted from the female parent to her progeny (vertical) and outbreaks have been diagnosed in fish at Bonneville Hatchery with significant mortality. Consequently, examination of brood stock and juveniles for EIBS was designed into the disease monitoring scheme for Umatilla chinook stocks. *Renibacterium salmoninarum*, the etiological agent of bacterial kidney disease (BKD), is also prevalent in these chinook stocks and is known to be vertically transmitted (Evelyn et al. 1986). An aggressive monitoring regimen for *R. salmoninarum* using enzyme-linked immunosorbent assay (ELISA) technology was therefore incorporated in the Umatilla Hatchery fish health monitoring and evaluation project. Systemic bacterial infections, such as those caused by *Yersinia ruckeri*, *Aeromonas salmonicida*, *Flexibacter psychrophilus*, *F. columnaris* and other aeromonad-pseudomonad agents, are also common in chinook and steelhead populations. Rearing densities and stress play an important role in the occurrence and severity of these infections, as well as for bacterial and environmental gill disease. Thus, monitoring for these agents and conditions is a component of the systematic fish health evaluation program. While external gill and body parasites might not be expected in a hatchery system with well water and with netting effective in preventing intrusion by birds, fish at Irrigon Hatchery adjacent to Umatilla have experienced parasite infestations in spite of having well water and bird netting. Surveillance for external parasites, then, is also an integral part of monthly and preliberation monitoring.

METHODS

Juvenile Monthly Monitoring

Each month up to five fresh dead or moribund fish of each species and stock in two series of Oregon and Michigan raceways, identified as index raceways (91.91 Umatilla steelhead were only in three Michigan raceways), were examined as follows. Wet mounts of excised gill arches and scrapings from the body surface were examined at 100X and 400X magnification by light microscopy for external parasites, bacteria and tissue structure. Inocula from gills were struck on tryptone-yeast extract agar (TYE) to detect gill disease bacteria and inocula from kidneys were struck on TYE and tryptic soy agar (TSA) to isolate systemic bacterial and fungal pathogens. Blood smears from moribund chinook were stained with pinacyanol chloride (Leek 1987) and examined by light microscopy at 1,000X magnification for inclusions typical of EIBS. When fish were larger than 4 g, whole kidney was aseptically excised, placed in a sterile whirl-pak bag and processed for the enzyme-linked immunosorbent assay (ELISA) for detection of *R. salmoninarum* antigen as described below. If fish were smaller than 4 g, smears of kidney tissue were made on microscope slides and examined for *R. salmoninarum* by the direct fluorescent antibody (DFAT) method (Banner et al. 1982). Quantification of *R. salmoninarum* levels using the DFAT was done by scanning a stained smear for two minutes at 400X magnification and rating the number of fluorescing cells from 0 to 4+ as follows. Zero indicates no cells were observed, 1+ indicates less than 10 cells per microscope field, 2t indicates 10-100 cells per field, 3-t indicates 100-1,000 cells per field and 4t indicates greater than 1,000 cells per microscope field.

Five grab-sampled normal-appearing fish from a lower raceway of each index series were also examined monthly for external parasites and R. salmoninarum by the same methods as for fresh dead and moribund fish described above.

Juvenile Preliberation Monitoring

Within four weeks before release or transfer to acclimation ponds, 30 fish of each species and stock from each index raceway were sampled for R. *salmoninarum* by ELISA, as described below, and chinook were sampled for EIBS, as described under monthly monitoring. Gill arch and body scraping wet mounts from two normal-appearing fish from the lower raceway of each index series were examined for external parasites, bacteria, and tissue structure, also described under monthly monitoring. Sampling for viruses by cell culture assays was done using gill/kidney/spleen tissue homogenates as five fish pools from 30 fish of each species and stock from a cross-section of Michigan raceways and 30 fish from a cross-section of Oregon raceways. Methods used were those described by Amos (1985) in the Fish Health Section Bluebook. Gill arches for histological examination of each species and stock were taken from 10 fish each from a cross-section of upper, middle, and lower Michigan raceways, and from upper and lower Oregon raceways. The fish were anesthetized in a benzocaine bath, then a gill arch was excised with scissors. Gill arches were placed directly into Bouin's fixative and held for 1-2 weeks. Then they were transferred to 70% ethanol until delivery to the Oregon State

University Veterinary Diagnostic Laboratory for embedding, sectioning, mounting, and staining with hematoxylin and eosin.

Juvenile Disease Outbreak Monitoring

Inocula from kidneys, gills and lesions of moribund fish were struck on TSA and TYE agar plates. Predominant bacteria typical of F. *psychrophila*, which grew on TYE agar, were confirmed by testing them against *F. psychrophila* polyclonal 'rabbit anti-serum using the rapid slide agglutination method. Diagnostic procedures generally follow those described in the Fish Health Section Bluebook (Amos 1985).

Brood Stock Monitoring

Spawning‘adults of each species and stock used as the Umatilla Hatchery brood stock were sampled for culturable viruses, *R. salmoninarum*, and EIBS virus. Samples from all adults or weekly from a portion of the spawning population were assayed. Individual or pooled sex fluids were used predominantly for viral assays; when IHN virus prevalence rates became high, weekly subsampling was implemented. Viral assay methods were identical to those described for preliberation monitoring. Because ELISA equipment was not available during the 91 brood year monitoring, the DFAT method on smears made from pellets of centrifuged ovarian fluid samples from individual spawned females were used for *R. salmoninarum* assays. Kidney smears were used when prespawning mortality was sampled. Methods for EIBS were those as described under monthly monitoring.

Enzyme-linked Immnosorbent Assay

The enzyme-linked immunosorbent assay (ELISA) methodology for the Umatilla Hatchery fish health monitoring project was adopted from Pascho and Mulcahy (1987). A complete description of that methodology follows. ELISA 96-well plates (Corning Glass Works) were coated with 200 ul/well of a preparation made from a lyophilized commercial anti-Renibacterium *salmoninarum* polyclonal antibody (rehydrated according to product label), which was diluted 1:1,000 in a commercial coating solution (diluted 1:10 in reagent grade water). (Kirkegaard & Perry Laboratories ELISA reagents were used where commercial products are indicated.) These coated plates were incubated overnight at 4°C in a humid chamber followed by a wash cycle consisting of five rinses with 375 ul/well of a commercial wash solution (0.04 M imidazole and 0.4% Tween-20 in buffered saline), diluted 1:20 with reagent grade water, on a BioTek EL403 Autowasher. Thirty-second soak intervals were allowed between each wash.

Kidney samples to be assayed by ELISA were weighed to the nearest hundredth or thousandth of a gram and homogenized at a 1:16, 1:8 or 1:4 weight/volume dilution in phosphate buffered saline solution containing 0.05% Tween-20 (PBS-T20). Diluted homogenates where then aliquoted into 2.0 ml polyproplyene vials, heated at 100°C for 10 minutes in a water bath, then centrifuged for 5 minutes in a micro-centrifuge. These samples were then frozen at –85°C until ELISA analyses were done. After thawing to room

temperature, the samples were centrifuged as above. Supernatant aliquots of 200 ul/well were inoculated onto the coated ELISA plates. Replicate wells were inoculated if sufficient sample volume was available. Plates were incubated for three hours in a humid chamber in the dark at room temperature then washed as the coated plates described above. A lyophilized commercial anti-R. salmoninarum peroxidase labeled polyclonal antibody (rehydrated according to product label) was prepared by diluting the rehydrated antibody 1:2,000 in a commercial milk diluent solution (diluted,1:20 in reagent grade water). A Lab Systems Autodrop model 830 was then used to add 200 ul of this conjugated second antibody to each sample well, Plates were incubated for two hours in the dark in a humid chamber then washed as above. The Autodrop was then used to add 200 ul/well of a solution designated ABTS (commercial peroxidase substrate mixed 1:1 with commercial peroxidase solution B just prior to use) to the plate. Plates were incubated for 20 minutes at $37^{o}C$ in the dark, followed immediately by addition of 100 ul/well, with the Autodrop, of a commercial ABTS peroxidase stop solution diluted 1:2.5 in reagent grade water. A BioTek EL312E BioKinetics reader was then used to read the optical density (OD_{405}) of each well at 405 nm. The OD_{405} of sample wells was subtracted from the mean OD_{405} of eight control wells that had received 200 ul/well PBS-T20 buffer as sample inoculum rather than tissue homogenates or *R. salmoninarum* antigen, otherwise these were treated identical to sample wells.

Several other types of control well treatments *were* prepared for each ELISA assay. Replicate positive control wells were inoculated as sample well above, with a preparation made from a lyophilized commercial *R. salmoninarum* antigen (rehydrated according to product label) diluted 1:1,000, 1:500, 1:100 and 1:10 in PBS-T20. Four wells designated "substrate control" received only diluents for the coating and conjugated antibodies, PBS-T20 as sample and all other reagents. Four wells designated "conjugate control" received only diluent for the coating antibody, PBS-T20 as sample and all other reagents. Results of OD_{405} readings of all wells were printed from the BioTek EL312E reader.

RESULTS

Juvenile Monthly Monitoring

External parasites were not detected in wet mounts of gill or body scrapings from a total of 128 fish examined by microscopy, with the possible exception of a single Ichtyobodo *(Costia)*. Gill condition was normal by gross examination. Bacteria typical of types causing gill disease were isolated at relatively low levels from 15.5% of steelhead (Appendix Table A-4), 14.3% of fall chinook (Appendix Table A-5), and 26.9% of spring chinook (Appendix Table A-6) examined. Anemia from EIBS was not indicated. Flexibacter psychrophilus was the first and most frequent fish pathogen detected in fish at Umatilla Hatchery. This bacterial agent, which causes cold water disease (CWD), was isolated from a fresh dead Umatilla summer steelhead (91.91) on 26 November 1991 (Appendix Table A-4). Isolations of F. *psychrophilus* were made from 15.4% (6/39) of this stock in monthly examinations, however no CWD outbreaks occurred. Only 3.4% (2/59) of Bonneville fall chinook (95.91) were positive for *F. psychrophilus* during monthly monitoring (Appendix Table A-5) even though this stock did undergo an epizootic of CWD as described below under

Juvenile Disease Outbreak Monitoring. Carson spring chinook (75.91) had a 7.02 (1/51) prevalence of *F. psychrophilus* systemically, however this bacterium was detected on 22.6% (7/31) of cultures from gill inocula of this stock (Appendix Table A-6). Opportunistic aeromonad-pseudomonad bacteria were isolated only from decomposing dead fish. Distinct patterns of differences between Oregon and Michigan raceways in the occurrence of *F. psychrophilus* gill bacteria were not discerned in the initial rearing phases.

Assays for Renibacterium salmoninarum by the ELISA and DFAT

Thirty-nine moribund or fresh dead and 20 grab-sampled normal-appearing Umatilla summer steelhead (91.91) were tested by ELISA for *R. salmoninarum* during the four months of monthly monitoring while the fish were in three Michigan raceways (M5A, M5B and M5C; Appendix Table A-7). Kidney tissue from these was homogenized at a 1:8 dilution; the mean OD reading for moribund/fresh dead fish was 0.011 and the range was 0.000-0.086. One of the 20 normal fish from raceway M5C had an OD reading of 0.586, indicating that a moderate level of *R. salmoninarum* antigen was present. The other 19 normal fish had a mean OD reading of 0.011 and a range of 0.000-0.025. Based on these data, 1.7% (1/59) of the steelhead tested were *R. salmoninarum* positive.

Twenty-five Bonneville fall chinook (95.91) salmon from two Oregon raceways (03A and 03B) and 15 fall chinook from three Michigan raceways (M3A, M3B and M3C) were examined in March and April of 1992 and were negative for *R. salmoninarum* by the DFAT (Appendix Table A-8). In April, five grab-sampled normal-appearing fish from each of a lower Oregon (038) and Michigan (M3C) raceway were tested by ELISA using kidney samples diluted 1:16. Fish from the Oregon raceway had OD readings in the range of 0.006-0.038; those from the Michigan raceway had a range of 0.002-0.162. Means were 0.021 and 0.040 for the Oregon and Michigan raceways, respectively. Of the 10 fish tested by ELISA, only one (10%) with an OD reading of 0.162 was considered *R. salmoninarum* positive.

Four moribund or fresh dead Carson spring chinook (75.91) salmon were examined and negative for *R. salmoninarum* by the DFAT in January of 1992 while they were in two Oregon raceways (Appendix Table A-9). In February, March and April, a total of eight moribund/fresh dead from Oregon raceways and 39 from Michigan raceways were examined by ELISA (Appendix Table A-9). During the same three months, 15 grab-sampled normal-appearing fish from lower Oregon raceways and 20 from lower Michigan raceways were similarly tested. Of all spring chinook juveniles examined, only two (2.4%) moribund/fresh dead fish sampled in March had ELISA readings indicating *R. salmoninarum* infection. One was from an upper Oregon raceway (04A) with an OD reading of 0.152, and one was from an upper Michigan raceway (M7A) with a reading of 0.240. For all others sampled, the range was 0.001-0.055 for Oregon raceways and 0.000-0.060 for Michigan raceways. Means, including the two *R. salmoninarum* positives, were 0.017 and 0.014 for Oregon and Michigan raceways, respectively.

Juvenile Preliberation Monitoring

External parasites were not detected in wet mounts of gill or body scrapings examined by microscopy from a total of 22 fish. Gill condition was

normal by gross examination. Fine structure analysis of gill tissue by histology is in progress. No culturable viral agents were detected by cell culture assays. Inclusions typical of EIBS virus were observed at very low levels (four inclusions per blood smear) in 0.33% (1/300) of blood smears from Carson spring chinook (75.91) juveniles and in 0% (0/300) of those from Bonneville fall chinook (95.91) juveniles.

Assays for Renibacterium salmoninarum by the ELISA

Two of 30 (6.7%) Umatilla summer steelhead (91.91) juveniles in raceway M5B had OD readings of 0.124 and 0.139 (Appendix Table A-10) indicative of low levels of *R.* salmoninarum antigen. The other 28 fish from M5B, 30 from M5A, and 30 from M5C had readings less than 0.089, indicating that they were negative for or had very low levels of *R. salmoninarum* antigen. Mean ELISA OD readings for the 30 fish from each raceway were 0.012, 0.026 and 0.008 for M5A, M5B and M5C, respectively. These fish did not receive antibiotic prophylaxis for *R. salmoninarum* and 2.2% (2/90) were considered positive.

One of 120 (0.8%) Bonneville fall chinook (95.91) juveniles from four Oregon raceways had an OD reading greater than 0.200 (0.209) while 2/180 (1.1%) in six Michigan raceways had similar readings (0.209 and 0.216) (Appendix Table A-11). In the range of 0.100-0.199, there were 6/120 (5.0%) in Oregon raceways and 8/180 (4.4%) from Michigan raceways. Readings from the remaining 113 (94.2%) fish in Oregon raceways and 170 (94.4%) from Michigan raceways had OD readings of less than 0.100. Mean OD readings for the 30 fish from each Oregon raceway were 0.009, 0.036, 0.026 and 0.025 for 02A, 02B, 03A and 038, respectively. For the six Michigan raceways, means were 0.026 0.034, 0.037, 0.049, 0.045 and 0.022 for M2A, M2B, M2C, M3A, M3B and M3C respectively. Because of their small size, kidneys from these fish for ELISA were processed at twice the dilution (1:16) as those from steelhead. Since ELISA readings were higher in fall chinook samples processed at twice the dilution as steelhead, higher levels of *R. salmoninarum* antigen are indicated in the fall chinook. Oral oxytetracyline prophylaxis for CWD had been administered to these fish from 1 March 1991 through 11 March 1991 by feeding 4% TM_{100} at 3% body weight of diet per day.

In Carson spring chinook (75.91) juveniles, only 2/180 (1.1%) from six Michigan raceways had OD readings of 0.100 or greater while the remaining 178 (98.9%) from Michigan raceways and 120 (100%) from four Oregon raceways all had readings less than 0.100 (Appendix Table A-12). Means for 30 fish from each Oregon raceway were 0.008, 0.011, 0.006 and 0.012 for 04A, 048, 05A and 05B, respectively. For Michigan raceways, means were 0.016, 0.013, 0.019, 0.014, 0.014 and 0.012 for M6A, M68, M6C, M7A, M7B and M7C, respectively. Kidneys from these fish were processed at the same 1:16 dilution as were those from fall chinook. The spring chinook received a prophylatic feeding of erythromycin as Gallimycin 50 for 14 consecutive days in mid-January at a level of 224 mg/kg body weight per day followed by another 'I-day feeding from 28 January through 4 February at 194 mg/kg body weight per day. It should be noted that future erythromycin dosages will be about half that used for the 91.91 Carson subyearling spring chinook to meet requirements of a Federal Drug Administration Investigational New Animal Drug permit.

Juvenile Disease Outbreak Monitoring

A CWD epizootic was diagnosed in the Bonneville fall chinook (95.91) in both Oregon and Michigan raceways during coded-wire tagging and fin clipping operations on 14 April 1992. Oral oxytetracycline therapy was implemented by feeding TM 00 as 18 gms/100 lbs of fish per day at a rate of 3-3.5% body weight of iet per day for 14 days (132-154 mg/kg body weight per day), epizootic was controlled or had run its course by late April when losses returned to normal. These fish had received prophylactic oxytetracycline for 10 days in early March. This prophylaxis was therefore ineffective for preventing the CWD outbreak in mid-April.

Brood Stock Monitoring

The Umatilla summer steelhead (91.00) broodstock was negative for replicating agents, including IHN virus, by cell culture assays. Individual sex fluid samples from 100% of the females (64) and males (63) spawned were tested for IHN virus. Three-fish tissue pools from all females spawned were also screened and negative for replicating agents. Sixty females sampled for EIBS virus were negative and 1..7% (1/60) of smears made from ovarian fluid cell pellets from females were positive at a low level (1+) for *R. salmoninarum* by the DFAT.

The Umatilla summer steelhead (92.00) broodstock was negative for replicating agents, including IHN virus, by cell culture assays. Individual sex fluid samples from 100% of the females (86) and males (86) spawned were tested for IHN virus. Two or three-fish tissue pools from a total of 70 females and males spawned were also screened and negative for replicating agents. Sixty females were sampled for EIBS virus;-1.7% (1/60) had very-large inclusions in red blood cells that stained identical to those typical of EIBS inclusions, although they were definitively larger. Seventy-three spawned adults and one adult mortality were sampled for *R. salmoninarum* by the ELISA (Appendix Table A-13). One of the spawned adults (1.4%) had a very high OD_{405} reading of 2.336, indicating a high level of antigen. The other 73 fish (98.6%) had readings of 0.075 or less, indicating very low or negative antigen levels. Mean ELISA OD readings for these 73 fish were 0.021 with a range of *0.003-0.075*.

Eggs to Umatilla Hatchery from the Bonneville fall chinook (91.00) broodstock were spawned on 18 November 1991 and 21 November 1991. Virus sampling on these dates showed that 3.1% (5/164) of milt samples from individual males were IHN virus positive; 54.5% (84/154) of three-fish ovarian fluid sample pools from females were positive (Appendix Table A-14). Thus 84% (26/31) of the family groups from these spawnings had at least one IHN virus positive parent. On 13 November 1991 and 18 November 1991 spawned females were sampled for EIBS virus. Inclusions were observed in 16/57 (28.1%) of blood smears from the first date and in 7/37 (19.0%) from the second date, resulting in a cumulative prevalence of 24.5%. The prevalence of *R. salmoninarum* was 0% (0/60) in subsamples of the total spawning population and 30.0% (6/20) in prespawning mortality as determined by the DFAT using smears from ovarian fluid cell pellets or kidney smears (Appendix Table A-15). Two of the six positives were rated at the highest positive level (4+) for the bacterium and the other four rated as low level positives (1+ and 2+).

The Carson spring chinook (91.00) broodstock for Umatilla Hatchery was spawned and sampled for IHN virus as four-female and two-to four-male family groups. An 83.3% (300/360) prevalence of the virus was detected in ovarian fluids from females and 27.6% (59/214) of the male milt samples were IHN virus positive (Appendix Table A-16). All family groups had at least one parent that was IHN virus positive. Two of 75 (2.7%) blood smears had inclusions diagnostic for EIBS virus. Of 360 smears made from ovarian fluid cell pellets assayed for *R. salmoninarum* by the DFAT, 3.9% (14/360) were positive (Appendix Table A-17). Four of the 14 positives were rated at the highest positive level (4+) for the bacterium, two at the next level (3+), two at the next level (2+), and six were rated at the lowest positive level (1+).

DISCUSSION

The objectives of the fish health monitoring portion of the Umatilla Hatchery monitoring and evaluation study focus on three areas. First, to systematically document the occurrence, incidence and prevalence of any infectious or non-infectious diseases in juvenile fish at the hatchery. Second, to determine cause of diseases as they occur and implement remedial measures to minimize losses, and to recommend preventative and prophylatic measures so that the onset of disease is prevented. Third, to monitor broodstock populations used for hatchery production, which may be infected with or are carriers of certain infectious agents known or suspected to be vertically transmitted. Ultimately, data acquired from pursuing these objectives will be used to develop disease profiles of species and stocks reared under the different rearing regimens at Umatilla Hatchery. Recommendations and adjustments could then be made to mediate impacts on survival due to impaired health or disease.

To accomplish the first objective, monthly and preliberation monitoring was conducted during the initial rearing phases. No definitive differences were discernible for any infectious or disease process in fish reared under the diverse conditions at Umatilla Hatchery. The initial rearing regimens were of relatively short duration, especially for subyearling chinook, and the production program was implemented at levels well below expectation. At full production and with longer term rearing for steelhead and yearling spring chinook, any differences in the occurrence of disease should become measurable.

The potential for outbreaks of bacterial CWD and bacterial gill disease was indicated from monthly monitoring. The causative agent of CWD, F. *psychrophilus*, and bacteria typical of those implicated in gill disease epizootics were occasionally isolated from all species and stocks. Thus, subtle or sudden environmental alterations could produce concomitant physiological changes in the fish predisposing them to disease outbreaks. Intensive environments tend to hold the fish at risk, especially when pathogens are present, and unpredictable environmental changes can have deleterious or catastrophic consequences if conditions are not corrected. Frequently, handling fish in intensive environments also results in outbreaks of infectious disease when the causative agent is harbored within the population.

External parasites were not observed on fish during monthly or preliberation monitoring, however continual surveillance for these agents is important. At Irrigon Hatchery, which is adjacent to Umatilla Hatchery and is also supplied with well water, external parasites were not detected on fish in the initial few rearing cycles. Then, *Ichthyophthirius* and *Ichtyobodo* infestations on steelhead were diagnosed over several consecutive years, often at levels requiring formalin treatments. Bird intrusions were common and the original bird netting was replaced. Parasites have not been observed on fish at Irrigon since. Therefore, monitoring for parasites and maintaining the integrity of the bird netting at Umatilla is warranted.

An outbreak of bacterial CWD did occur at Umatilla Hatchery in the Bonneville fall chinook while they were distributed among six Oregon and six Michigan raceways in mid-April. Based on the history of this stock at Bonneville, CWD was not unexpected and, in fact, the fish had received oxytetracycline prophylactically five weeks earlier. The cumulative losses specifically to CWD are impossible to even estimate. Loss comparisons between Oregon and Michigan raceways also have no basis for comparison for several reasons. Body tagging, fin clipping, coded-wire tagging and raceway-to-raceway exhanges of fish were all ongoing before and during the epizootic of CWD. These handling and marking procedures were at different times, intervals and intensities between fish in Oregon and Michigan raceways. Thus, although the general observation was that the loss from disease was more severe in Michigan raceways and more attributed to handling in Oregon raceways, the compromising factors do not allow a legitimate comparison. It would be informative to have non-handled control populations to assess the impact of handling on the onset and the severity of CWD in manipulated groups. The future use of oxytetracycline for CWD prophylaxis and therapy in salmonid fish will likely be more restrictive to meet Federal Drug Administration requirements. Minimizing losses resulting from handling, therefore, may depend more heavily upon hatchery practices rather than antibiotic mediated control.

Renibacterium salmoninarum antigen was detected at relatively low concentrations and at low prevalence in juvenile steelhead and both chinook stocks by ELISA during monthly and preliberation monitoring. The source of the bacteria producing a positive reaction in juveniles is presumed to be the female parents via vertical transmission. It must be emphasized that ELISA confirms the presence of a soluble protein produced by *R. salmoninarum* and provides only presumptive evidence for ongoing infection by viable bacteria. No gross kidney lesions were observed in any of the fish tested, which would be expected given the low ELISA readings, even in those fish presumed to be positive. ELISA OD readings of 0.100 or greater are strongly correlated with infection and thus it is assumed most or all of the fish with such readings were infected. ELISA readings less than 0.100 may indicate very low levels of infection or lack of infection.

The subyearling spring chinook received dietary erythromycin prophylaxis for *R. salmoninarum* from mid-January through early February for 21 days. Erythromycin is known to accumulate in fish tissues at concentrations thought to be sufficient to suppress *R. salmoninarum* growth during, and for some period following, administration of the antibiotic (Moffitt and Schreck 1988) This may account, in part, for the low levels of antigen detected in the spring chinook. The subyearling fall chinook were given oxytetracycline both

prophylactically and for CWD therapy in March and April. Some suppression of *R. salmoninarum* is also thought to occur with this antibiotic. Therefore, it is possible that low *R. salmoninarum* antigen levels resulted from these treatments. It is also important to consider that kidney samples from both subyearling chinook stocks, because of their small size, were diluted at 1:16 rather than 1:8. Levels of *R. salmoninarum* antigen in chinook, therefore, may be significantly greater than indicated. Efforts are ongoing to improve methodology when 1:16 diluted samples must be used.

Initial comparisons of the same samples diluted 1:8 and 1:16 indicated that there did not appear to be a simple linear relationship between ELISA OD_{40} and kidney dilution. These observations are contrary to those of Rockey et a5. (1991) who did see a linear relationship of ELISA OD_{405} and *R. salmoninarum* soluble protein concentration. In those studies, however, the antigen was in *R. salmoninarum* cell culture supernatants; samples were not heated and a monoclonal antibody was used for ELSIA. The ELISA protocol for Umatilla Hatchery, adopted from Pascho and Mulcahy (1987), uses antigen contained within kidney tissue homogenates, calls for heating samples to 100°C, and uses a polyclonal antibody for ELISA. Since the monoclonal ELISA reagent used in the studies reported by Rockey et al. (1991) has recently become available,, comparisons between it and the polyclonal ELISA system will be made. Investigations are also in progress to determine if there is a correlation factor that would allow the transformation of ELISA OD data between samples diluted 1:4, 1:8 and 1:16, and to determine if there is a minimum level of antigen to which this correlation is applicable.

Inclusions in red blood cells typical of EIBS virus were observed in only 1/600 juvenile chinook examined at preliberation and this fish did not appear to be anemic. During monthly monitoring, there were no indications of anemia nor were chronic secondary infections associated with EIBS evident. Whether the virus causing EIBS could have been present in these fish without manifesting itself as inclusions in red blood cells or producing an anemic condition, is unknown. The Bonneville fall chinook adults are known to consistently have a high prevalence of typical EIBS inclusions and, in fact, subsamples from the 91.00 brood had a 25% prevalence. Latent infection of juveniles with this virus is therefore plausible, and activation of infection at some later lifestage could affect their survival.

The Umatilla summer steelhead (91.00) broodstock was negative for EIBS virus, IHN virus and other replicating agents detected by cell culture assays. Only one female tested positive for *R. salmoninarum* at very low levels. The progeny from these were also negative for IHN virus and other replicating agents; they showed no evidence of EIBS infection, and had low levels and prevalence of R. salmoninarum, as did the parental stock.

Both chinook broodstocks for the 91.00 subyearlings at Umatilla had a high prevalence of IHN virus, however the virus was not detected in the progeny. This is consistent with controlled laboratory experiments and production trials conducted by the Oregon Department of Fish and Wildlife over the past decade (Engelking et al. 1991; LaPatra et al. 1991). In no instance where eggs from IHN virus positive parents have been disinfected with iodophor, and incubated and early reared on IHN virus-free water, have progeny developed clinical IHN disease or tested positive for the virus. Evidence for vertical transmission in sockeye salmon in Alaska, however, has been reported

by Meyers et al. (1990). The failure to obtain similar results in Oregon may relate to variability in species susceptibility to IHN among salmonid fish, to IHN virus strain variation between geographical areas, or to the probability of a rare event such as vertical transmission to occur. The benefit from achieving fish production goals by using gametes from IHN virus positive parents would appear to outweigh the risk of IHN epizootics in juveniles (LaPatra et al. 1991). What is clear from the chinook broodstock sampling data for Umatilla Hatchery (Appendix Tables A-14 and A-16) is that if gametes from IHN virus positive parental groups were not used, production quotas would be impossible to achieve.

From the *R. salmoninarum* incidence and prevalence data obtained by the DFAT on samples from the 91.00 brood chinook adults, it is assumed that egq. from only a few high level positive females were incorporated into the Umatilla Hatchery production. Progeny from females infected at such high levels often develop clinical BKD as fry or fingerlings and are eliminated from the population as mortality. In the sequela of the disease process, however, they also serve as reservoirs of infection for others in the population. During monthly and preliberation monitoring, no fish with gross lesions or ELISA readings indicative of lethal *R. salmoninarum* infection were encountered. Possibly these were eliminated as alevins or fry before they had reached sufficient size for ELJSA. The low prevalence of juveniles testing positive for *R. salmoninarum* at preliberation correlates well with the prevalence seen in both chinook parental stocks. Erythromycin prophylaxis at dosages used for the juveniles should also significantly contribute to reduced antigen levels in these subyearling fish. Data collected on the longer term reared yearling spring chinook may provide better insight into the potential impacts that BKD may have on chinook populations at Umatilla Hatchery.

The opportunity for prospective epidemiology (Klontz 1993) in a fish production program is a unique feature of the Umatilla Hatchery monitoring and evaluation study. Systematic monitoring of fish populations used as stocks at a new facility for the occurrence of pathogens and disease conditions has rarely been done. Even more unusual is the integration of these activities with other intensive hatchery monitoring and evaluation studies. Using this integrated approach, any rearing conditions that enhance disease processes or result in impaired survival because of disease, should be identified and, where possible, corrected.

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APPENDIX A

Appendix Table A-1. Number of Umatilla summer steelhead (91.91) juveniles sampled per raceway in Michigan series 5 (M5A, M5B and M5C) during monthly monitoring.

Date sampled	M5A[1]	M5B[1]	M5C[1]	M5C[2]
11-91	5	0	2	5
12-91	5	2	4	5
1-92	5	5	4	5
2-92	4	2	1	5

1 *Moribund or fresh dead fish.*
2 Normal healthy appearing fish.

Appendix Table A-2. Number of Bonneville fall chinook (95.91) juveniles sampled per raceway in Oregon series 1, 2 and 3 (O1A, O1B, O2A, 028, O3A and O3B), and in Michigan series 2 and 3 (M2A, M2B, M2C, M3A, M3B and M3C) during monthly monitoring.

Date sampled	O1A[1]	O1B[1]	O1B[2]	O2A[1]	O2B[1]	O2B[2]	O3A[1]	O3B[1]	O3B[2]	M2A[1]	M2B[1]	M2C[1]	M2C[2]	M3A[1]	M3B[1]	M3C[1]	M3C[2]
2-92	-	-	-	5	5	3	5	5	3								
3-92	-	5	0	-	-	-	5	5	5								
4-92	-	-	-	-	-	-	5	5	5					5	5	5	5

1 Moribund or fresh dead fish.
2 Norma7 healthy appearing fish.

Appendix Table A-3. Number of Carson spring chinook (75.91) juveniles sampled per raceway in Oregon series 4 and 5 (04A, 04B, 05A and 05B), and in Michigan series 6, 7 and 8 (M6A, M6B, M6C, M7A, M7B, M7C, M8A, M8B and M8C) during monthly monitoring.

Date sampled	04A[1]	04B[1]	04B[2]	05A[1]	05B[1]	05B[2]	M6A[1]	M6B[1]	M6C[1]	M6C[2]	M7A[1]	M7B[1]	M7C[1]	M7C[2]	M8A[1]	M8B[1]	M8C[1]	M8C[2]
1-92	2	2	0															
2-92				5											5	5	5	5
3-92	1	0	5	0	0	5	2	0	1	5	5	1	2	5				
4-92				2	0	5					5	5	3	5				

1 *Moribund* or *fresh dead fish.*
2 *Normal healthy appearing fish.*

Appendix Table A-4. Proportions and prevalences (%) of bacterial agents isolated from moribund or fresh dead Umatilla summer steelhead (91.91) **during monthly juvenile fish health monitoring.**

Date sampled	Raceway	Systemic bacteria[1]		Gill bacteria[2]
		F. psychrophilus	APS	
11-91	M5A	1/5 (20)	0/5 (0)	0/5 (0)
	M5B	ND[3]	ND	ND
	M5C	2/2 (100)	0/2 (0)	0/2 (0)
12-91	M5A	0/5 (0)	0/5 (0)	0/1 (0)
	M5B	0/2 (0)	0/2 (0)	0/2 (0)
	M5C	0/4 (0)	0/4 (0)	0/1 (0)
1-92	M5A	1/5 (20)	0/5 (0)	1/5 (20)
	M5B	1/5 (20)	1/5 (20)	1/1 (100)
	M5C	1/4 (25)	0/4 (0)	1/2 (50)
2-92	M5A	0/4 (0)	0/4 (0)	1/4 (25)
	M5B	0/2 (0)	0/2 (0)	0/2 (0)
	M5C	0/1 (0)	0/1 (0)	0/1 (0)

1 *The only systemic bacteria isolated from kidney smear inocula were* Flexibacter psychrophilus *and aeromonad-psuedomonad (APS) types.*

2 *These were determined to be significant only if yellow pigmented colonies were the prevalent type on smears made from gill inocula.*

3 *Indicates not done (ND) because no moribund or fresh dead fish were available.*

Appendix Table A-5. Proportions and prevalences (%) of bacterial agents isolated from moribund or fresh dead Bonneville fall chinook (95.91) during monthly juvenile fish health monitoring.

Date sampled	Racewav	Systemic bacteria' F. psychrophilus	Systemic bacteria' APS	Gill bacteria*
2-92	02A	0/5 (0)	1/5 (20)	ND[3]
	02B	0/5 (0)	1/5 (20)	1/3 (33)
	03A	0/5 (0)	0/5 (0)	ND
	03B	0/5 (0)	1/5 (20)	1/3 (33)
3-92	01A	ND		
	01B	0/4 (0)	0/4 (0)	ND
	03A	0/5 (0)	0/5 (0)	1/5 (20)[4]
	03B	1/5 (20)	0/5 (0)	0/5 (0)
4-92	03A	0/5 (0)	0/5 (0)	2/5 (40)
	03B	1/5 (20)	3/5 (20)	1/1 (100)
	M3A	0/5 (0)	0/5 (0)	0/5 (0)
	M3B	0/5 (0)	0/5 (0)	0/3 (0)
	M3C	0/5 (0)	0/5 (0)	0/5 (0)

1 *The only systemic bacteria isolated* from *kidney smear inocula were* Flexibacter psychrophilus *and aeromonad-psuedomonad (APS) types.*

2 *These were determined to be significant only if yellow pigmented colonies were the prevalent type on smears made from gill inocula.*

3 *Indicates not done (ND) because no moribund or fresh dead fish were available.*

4 *Some colonies were confirmed to* be F. psychrophilus *using polyclonal rabbit antiserum for the rapid slide agglutination test.*

Appendix Table A-6. Proportions and prevalences (%) of bacterial agents isolated from moribund or fresh dead Carson spring chinook (75.91) during monthly juvenile fish health monitoring.

Date sampled	Raceway	Systemic bacteria[1]		Gill bacteria[2]
		F. psychrophilus	APS	
1-92	04A	0/2 (0)	0/2 (0)	ND[3]
	04B	0/2 (0)	1/2 (50)	ND
2-92	05A	0/5 (0)	0/5 (0)	0/5 (0)
	M8A	0/5 (0)	1/5 (20)	0/5 (0)
	M8B	0/5 (0)	0/5 (0)	3/5 (60)
	M8C	0/5 (0)	2/5 (40)	0/5 (0)
3-92	04A	0/1 (0)	1/1 (100)	ND
	04B	ND	ND	ND
	05A	ND	ND	ND
	05B	ND	ND	ND
	M6A	0/2 (0)	1/2 (50)	ND
	M6B	ND	ND	ND
	M6C	0/1 (0)	0/1 (0)	1/1 (100)[4]
	M7A	0/5 (0)	1/5 (20)	ND
	M7B	0/1 (0)	0/1 (0)	ND
	M7C	0/2 (0)	0/2 (0)	1/1 (100)[4]
4-92	05A	0/2 (0)	1/2 (50)	0/1 (0)
	05B	ND	ND	ND
	M7A	0/5 (0)	0/5 (0)	
	M7B	1/5 (20)	0/5 (0)	5/5 (100)[4]
	M7C	0/3 (0)	0/3 (0)	2/3 (67)

1 *The only systemic bacteria isolated from kidney smear inocula were* Flexibacter psychrophilus *and aeromonad-psuedomonad (APS) types. These* were *determined to be significant only if yellow pigmented colonies were the prevalent type on smears made from gi17 inocula.*

2 *Indicates not done (ND) because no moribund* or *fresh dead fish were available.*

3 *Some colonies* were *confirmed to be* F. psychrophilus *using polyclonal rabbit antiserum for the rapid slide agglutination test.*

Appendix Table A-7. ELISA readings (OD_{405}) of kidney samples' from Umatilla summer steelhead (91.91) juveniles sampled during monthly monitoring from each of three Michigan raceways (M5A, M5B and M5C).

	ELISA OD_{405}			
Date sampled	M5A[2]	M5B[2]	M5C[2]	M5C[3]
11-91	.004	ND[4]	.010	.002
	.003		.010	.014
	.008			.009
	.004			.586
	.009			.013
12-91	.002	.007	**.012**	.008
	.014	.012	.004	.070
	.006		.024	.005
	.017		.005	.020
	.007			.ooo
1-92	.005	.005	**.012**	.003
	.017	.021	.016	.010
	.017	.009	.012	.011
	. 000	.006	.012	.003
	.006	.086		.025
2-92	.017	.003	.010	.002
	.005	.006		.003
	.005			.ooo
	.005			.002
				.000

1 ***Individual kidney samples were homogenized in PBS-Tween 20 buffer at a 1:8 weight/volume dilution.***

2 ***Moribund or fresh dead fish.***

3 ***Normal healthy appearing fish.***

4 ***Indicates not done (ND) because no moribund or fresh dead fish were available.***

Appendix Table A-8. DFAT results and ELISA readings (OD_{405}) of kidney samples from Bonneville fall chinook (95.91) juveniles sampled during monthly monitoring from two Oregon raceways (03A and 03B), and three Michigan raceways (M3A, M3B and M3C).

	ELISA OD_{405}						
Date sampled	03A[2]	03B[2]	03B[3]	M3A[2]	M3B[2]	M3C[2]	M3C[3]
3-92	0/5[4]	0/5[4]	0/5[4]				
4-92	0/54	0/5[4]	.038 .006 .038 **.015** .008	0/5[4]	0/5[4]	0/5[4]	.002 .011 .007 **.162** .020

1 ***Individua7 kidney samples were homogenized in PBS-Tween 20 buffer at a 1:16 weight/volume dilution for the ELISA.***
2 ***Moribund or fresh dead fish.***
3 ***Norma7 healthy appearing fish.***
4 ***Examined by the DFAT because of the small fish size.***

Appendix Table A-9. DFAT results and ELISA readings (OD_{405}) of kidney samples[1] from Carson spring chinook (75.91) juveniles sampled during monthly monitoring from four Oregon raceways (04A, 04B, 05A, and 05B), and nine Michigan raceways (M6A, M6B, M6C, M7A, M7B, M7C, M8A, M8B, and M8C).

	ELISA OD_{405}																
Date sampled	04A[2]	04B[2]	04B[3]	05A[2]	05B[2]	05B[3]	M6A[2]	M6B[2]	M6C[2]	M6C[3]	M7A[2]	M7B[2]	M7C[2]	M7C[3]	M8A[2]	M8B[2]	M8C[2]	M8C[3]
1-92	0/2[4]	0/2[4]																
2-92				.004 .009 .008 .004 .002											.002 .003 .007 .001 .000	.000 .000 .009 .005 **.000**	.055 .001 .000 .000 .026	.002 .005 .005 .025 .001
3-92	.152		,001 .010* .014* .009* .007*			,001 .002 .004* **.011**	**.060** .042*		.008*	.006* .007* .028* 005*	.012 .027 .011 .013	,007	.012* .013*	.008* .005* .009* **.006*** **.006***				
4-92				.055 .015		.008 .013 .008 .005 .032					.006 .008 ,013 .015 .034	,006 .005 ,005 .010 .014	.005 .004 .003	.005 .004 .007 .003 .003				

1 *Individual kidney samples were homogenized in PBS-Tween 20 buffer at a 1:16 weight/volume dilution for the ELISA. Those identified with an asterisk (*) were of sufficient weight to dilute 1:8 in buffer.*

2 *Moribund or fresh dead fish.*

3 *Normal healthy appearing fish.*

4 *Examined by the DFAT because of the small fish size.*

Appendix Table A-10. Preliberation ELISA readings (OD_{405}) of kidney samples[1] from 30 Umatilla summer steelhead (91.91) juveniles from each of three Michigan raceways (M5A, M5B and M5C). Means and ranges for each raceway are shown below the 30 individual sample readings. Fish in MSC were sampled on 2-26-92 at a mean body weight of 71 gms/fish, M5B on 4-l-92 at 78 gms and M5A on 4-29-92 at 83 gms.

Sample number	ELISA OD_{405}		
	M5A	M5B	M5C
1	.ooo	.003	.002
2	.ooo	.005	.002
3	.001	.005	.002
4	.002	.006	.003
5	.002	.007	.004
6	.002	.009	.004
7	.002	.010	.005
8	.002	.010	.005
9	.003	.012	.005
10	.003	.013	.005
11	.004	.016	.006
12	.004	.016	.006
13	.005	.016	.006
14	.005	.017	.006
15	.006	.018	.006
16	.007	.019	.006
17	.007	.019	.007
18	.007	.020	.007
19	.008	.021	.008
20	.008	.021	.008
21	.008	.023	.008
22	.008	.029	.009
23	.010	.030	.010
24	.011	.030	.010
25	.019	.031	.013
26	.020	.033	.015
27	.023	.042	.016
28	.026	.045	.019
29	.054	.124	.019
30	.089	.139	.022
Mean	.012	.026	.008
Range	.000-.089	.003-.139	.002-.022

1 ***Individual kidney samples*** were ***homogenized in PBS-Tween 20 buffer at a 1:8 weight/volume dilution.***

Appendix Table A-11. Preliberation ELISA readings (OD_{405}) of kidney samples[1] from 30 Bonneville fall chinook salmon (95.91) juveniles from each of four Oregon raceways (02A, 02B, 03A and 038) and each of six Michigan raceways (M2A, M2B, M2C, M3A, M3B and M3C). Means and ranges for each raceway are shown below the 30 individual sample readings. Fish were sampled on 5-12-92 at mean body weight ranges of 3.7-5.0 gms/fish in Oregon raceways and 5.1-6.1 gms/fish in Michigan raceways.

Sample number	ELISA OD_{405}									
	02A	02B	03A	03B	M2A	M2B	M2C	M3A	M3B	M3C
1	.OOO	.008	.OOl	.002	.000	.OOO	.OOO	.007	.005	.001
2	.OOO	.009	.004	.003	.OOO	.003	.000	.008	.007	.002
3	.002	.OlO	.005	.006	.003	.006	.004	.009	.007	.004
4	.003	.OlO	.007	.007	.003	.008	.006	.009	.008	.004
5	.003	.OlO	.007	.008	.004	.009	.008	.009	.009	.005
6	.003	.011	.008	.008	.005	.009	.009	.011	.010	.005
7	.004	.012	.009	.008	.005	.009	.012	.011	.010	.006
8	.004	.013	.009	.008	.005	.010	.012	.012	.012	.006
9	.004	.014	.009	.009	.008	.011	.013	.014	.013	.006
10	.004	.015	.010	.010	.008	.012	.016	.017	.013	.008
11	.005	.016	.010	.011	.009	.013	.017	.018	.013	.008
12	.005	.018	.010	.011	.009	.013	.020	.019	.017	.009
13	.006	.020	.010	.012	.010	.014	.020	.021	.023	.009
14	.006	.020	.012	.012	.011	.014	.021	.030	.024	.009
15	.007	.021	.013	.013	.012	.017	.023	.035	.025	.010
16	.007	.022	.014	.014	.012	.018	.034	.042	.036	.013
17	.007	.026	.014	.014	,014	.023	.039	.043	.040	.013
18	.007	.026	.015	.014	.014	.023	.048	.044	.049	.015
19	.008	.027	.016	.015	.015	.026	.049	.059	.051	.016
20	.009	.028	.016	.016	.016	.030	.050	.061	.056	.016
21	.009	.029	.017	.017	.018	.042	.051	.061	.059	.016
22	.011	.036	.018	.017	.022	.046	.063	.061	.060	.018
23	.012	.037	.019	.019	.026	.051	.064	.074	.067	.022
24	.013	.062	.021	.021	.026	.053	.065	.074	.073	.023
25	.014	.079	.035	.021	.038	.057	.067	.083	,075	.025
26	.016	.084	.058	.022	.044	.066	.071	.090	.078	.046
27	.017	.094	.080	.035	.049	.069	.075	.098	.086	.049
28	.017	.097	.103	.054	.083	.092	.079	.115	.097	.049
29	.018	.104	118	.121	.087	.106	.080	.132	139	.118
30	.048	.113	.118	.209	.216	.175	.093	.209	.180	.149
Mean	.009	.036	.026	.025	.026	.034	.037	.049	.045	.022
Range	.OOO-.008		.001-.048	.002-.113	.000-.118	.OOO-.209	.OOO-.216	.OOO-.175	.005-.093	.001-.209

1 ***Individual kidney samples were homogenized in PBS-Tween 20 buffer at a 1:16 weight/volume dilution.***

Appendix Table A-12. Preliberation ELISA readings (OD_{405}) of kidney samples' from 30 Carson spring chinook salmon (75.91) juveniles from each of four Oregon raceways (04A, 04B, 05A and 05B) and each of six Michigan raceways (M6A, M6B, M6C, M7A, M7B and M7C). Means and ranges for each raceway are shown below the 30 individual sample readings. Fish were sampled on 5-6-92 at mean body weight ranges of 14-15 gms/fish in Oregon raceways and 12-13 gms/fish in Michigan raceways.

Sample number	ELISA OD_{405}									
	04A	04B	05A	05B	M6A	M6B	M6C	M7A	M7B	M7C
1	.000	.001	.ooo	.ooo	.000	.004	.ooo	.002	.004	.ooo
2	.ooo	.004	.ooo	.ooo	.ooo	.005	.002	.003	.005	.ooo
3	.ooo	.004	. o o o	.001	.ooo	.006	.002	.005	.005	.001
4	.ooo	.005	.OOO	.002	.OOO	.006	.003	.005	.006	.002
5	.001	.005	.001	.002	.OOO	.006	.003	.006	.007	.002
6	.002	.005	.002	.002	.001	.006	.004	.006	.007	.002
7	.002	.006	.002	.002	.002	.007	.007	.007	.007	.002
8	.002	.007	.002	.003	.002	.009	.007	.007	.007	.003
9	.003	.007	.002	.003	.002	.009	.008	.008	.007	.003
10	.003	.007	.002	.003	.003	.010	.008	.009	.007	.003
11	.003	.008	.003	.003	.003	.OlO	.008	.010	.008	.004
12	.003	.008	.003	.004	.004	.010	.008	.011	.008	.004
13	.004	.009	.003	.004	.005	.011	.008	.011	.008	.005
14	.004	.009	.003	.005	.005	.011	.011	.012	.010	.005
15	.005	.009	.004	.005	.006	.011	.012	.012	.010	.005
16	.006	,009	.004	.005	.007	.012	.012	.012	.012	.007
17	.006	.011	.004	.007	.007	.012	.013	.012	.012	.009
18	.006	.011	.004	.009	.008	.013	.014	.013	.014	.010
19	.006	.011	.004	.009	.009	.014	.016	.014	.014	.010
20	.007	.012	.005	.010	.011	,014	.019	.014	.016	.011
21	.007	.013	.006	.011	.016	.014	.021	.016	.017	.011
22	.008	.014	.007	.011	.021	.016	.021	.016	.018	.011
23	.009	.015	.008	.011	.024	.016	.024	.017	.019	.016
24	.012	.016	.008	.016	.025	.016	.028	.018	.019	.019
25	.012	.019	.009	.019	.025	.021	.034	.019	.025	.020
26	.018	.019	.010	.020	.036	.022	.034	.021	.026	.023
27	.024	.019	.010	.023	.040	.022	.035	.025	.027	.027
28	.026	.020	.011	.030	.052	.026	.039	.025	.027	.030
29	.030	.023	.016	.040	.059	.028	.044	.035	.030	.040
30	.040	.026	.045	.085	.101	.037	.112	.039	.031	.085
Mean	.008	.011	.006	.012	.016	.013	.019	.014	.014	.012
Range	. o o o - .040	.001- .026	.000- ,045	. o o o - .085	. o o o - .101	.004- .037	.002- .112	.002- .039	.004- ,030	.000- .085

1 ***Individual kidney samples were homogenized in PBS-Tween 20 buffer at a 1:16 weight/volume dilution.***

Appendix Table A-13. ELISA readings (OD_{405}) of kidney samples' from 74 Umatilla summer steelhead 92 brood year adults.

Sample number	ELISA OD_{405}	Sample number	ELISA OD_{405}
1	0.019	38	0.023
2	0.022	39	0.042
3	0.015	40	0.017
4	0.020	41	0.075
5	0.018	42	0.024
6	0.013	43	0.015
7	0.019	44	0.025
8	0.025	45	0.015
9	0.013	46	0.009
10	0.012	47	**0.010**
11	0.023	48	0.015
12	0.054	49	0.014
13	0.045	50	0.037
14	0.018	51	0.027
15	0.042	52	0.003
16	0.010	53	0.005
17	0.010	54	0.005
18	0.032	55	0.020
19	0.020	56	0.030
20	0.014	57	0.011
21	0.011	58	0.012
22	0.040	59	0.034
23	0.005	60	0.014
24	0.018	61	0.051
25	0.009	62	0.020
26	0.012	63	0.009
27	0.037	64	0.014
28	0.007	65	0.037
29	0.019	66	0.017
30	0.029	67	0.020
31	0.008	68	0.003
32	2.336	69	0.005
33	0.016	70	0.016
34	0.022	71	0.010
35	0.021	72	0.040
36	0.018	73	0.039
37	0.025	742	0.014

Mean 0.053
Range O-003-2.336

1 Individual kidney samples were *homogenized in PBS-Tween 20 buffer at a 1:4 weight/volume dilution.*
2 Sample number 74 was an adult mortality.

Appendix Table A-14. Proportions and prevalences of infestious hematopoietic necrosis virus (IHNV) detected in ovarian fluid and milt samples collected from the 91 brood year Bonneville fall chinook salmon (95.00) spawned for Umatilla Hatchery production.

Date sampled	Proportion and prevalence (%) of IHNV	
	Ovarian fluid	Milt
11-18-91	12/60 (20.0)	0/54 (0)
11-21-91	72/94 (76.6)	5/110 (4.6)

[1] *Ovarian fluid samples were three-female pooled samples.*
[2] *Milt samples were from individual males.*

Appendix Table A-15. Proportions and prevalences of *Renibacterium salmoninarum* detected by the direct fluorescent antibody test in smears from ovarian fluid pellets (spawned females) or kidneys (prespawning mortality) in samples collected from the 91 brood year Bonneville fall chinook salmon (95.00).

Date sampled	Adult' status	*Renibacterium salmoninarum* positives	
		Proportion	Percent
11-1-91	AdS	0/30	0
11-5-91	AdS	0/30	0
N/A[2]	AdM	6/20[3]	30

[1] *AdS indicates spawned adults* and *AdM indicates prespawning mortality.*
[2] *Not applicable* as *prespawning mortality was collected throughout*
[3] *holding prior to spawning.*
Two of the six positives rated at the 1+ level for R. salmoninarum, *two at the 2+ level and two at the 4+ level.*